JUN 5 1912

SAN FRANCISCO "1915" THE EXPOSITION CITY

JOURNAL OF ELECTRICITY

POWER AND GAS

Devoted to the Conversion, Transmission and Distribution of Energy

Entered as second class matter May 7, 1906, at the Post Office at San Francisco Cal., under the act of Congress March 3 1879

VOL. XXVIII NO. 22 SAN FRANCISCO, JUNE 1, 1912 PER COPY, 25 CENTS

Motor Starting Rheostat

Type G Controller

Type U Controller

Pressure Regulator

Float Switch

Motor Field Rheostat and Relay

Dinkey Ventilated Controller

Type Q Brake

Form A Automatic Motor Starter

Automatic Machine Tool Controller

Form AS Automatic Motor Starter

Form AK Automatic Motor Starter

Form ASK Automatic Motor Starter

Form ASBK Automatic Motor Starter

Form ASB Automatic Motor Starter

PROBLEMS involving the control of Direct Current Motors are many and varied.

¶ This fact has led THE ELECTRIC CONTROLLER & MFG. Co. to standardize a line of apparatus that would adequately solve most of these problems.

¶ A distinct advantage is thus given the purchaser, through the fact that we can furnish extremely durable, capable and handsomely finished apparatus at a very reasonable price

Send us your problems for solution.

THE ELECTRIC CONTROLLER & MFG. CO.

NEW YORK-50 CHURCH ST. CLEVELAND, OHIO CHICAGO-1417 MONADNOCK BLK.
PITTSBURG-1539 OLIVER BLDG. TORONTO-1222 TRADERS BANK BLDG. BIRMINGHAM-627 BROWN-MARX BLDG.

Where to Buy It in the West, Pages 9, 10, 12. Alphabetical Index to Advertisers, Page 8.

MAKE ONE SOCKET DO THE WORK OF TWO

No Extra Wiring-No Labor
Simple-Durable
Just Screws into the Present Socket

FOR CONVENIENCE AND SATISFACTION IN ATTACHING ELECTRICAL DEVICES USE THE
BENJAMIN 9-0-3 ATTACHMENT PLUG
THE SHELL TURNS INDEPENDENT OF THE CORD. NO KINKED WIRE.

No 9-0-3
BENJAMIN SWIVEL ATTACHMENT PLUG

It would be difficult to conceive of a plant or community where any extensive use is made of electrical appliances, in which

Benjamin Lighting Specialties

do not play a prominent part. The removal of any one from the list of standard electrical supplies would be felt at once as a distinct loss to the trade. Central stations have increased their load through the ready introduction of current consuming devices, a result made possible by the use of these helpful accessories.

Many an engineer has found the solution of a difficult problem easy, because he had the "Benjamin" catalog at his elbow. The user of electricity has learned to familiarize himself with this line of "trouble-savers"—as they are now generally known—to such an extent that the name "Benjamin" has become a household word. The dealer who stocks Benjamin specialties, therefore has little difficulty in moving his goods. We have literature on each particular device.

Write For Our Lighting Specialty List
of

Plug Clusters
Attachment Plugs
Socket Extensions
Twin Sockets
Tungsten Adapters
Large Base Reducers
Plug Current Taps
W. P. Sockets, etc

BENJAMIN ELECTRIC MFG. CO.

New York
114-118 Liberty St.

Chicago
120-128 S. Sangamon St.

San Francisco
151 New Montgomery St.

Foreign Branches:

The Benjamin Electric, Ltd.,
1-aRosebery Ave., London, E. C., England

Benjamin Electric Mfg. Co.
64 York Street, Toronto, Canada

Snoqualmie Falls.

B 273 296

JOURNAL OF ELECTRICITY
POWER AND GAS
Devoted to the Conversion, Transmission and Distribution of Energy

VOLUME XXVIII SAN FRANCISCO, JUNE 1, 1912 NUMBER 22

[COPYRIGHT 1912 BY TECHNICAL PUBLISHING COMPANY]

PUGET SOUND TRACTION, LIGHT & POWER COMPANY'S SYSTEM

By Rudolph W. Van Norden
Member A. I. E. E., A. S. C. E.

Mt. Rainier From Electron Flume.

Map of Territory Served

A HISTORY of the development and use of electricity in the northwest corner of the United States and particularly adjacent to one of the world's most remarkable inland harbors, Puget Sound, would be but a repetition of the commercial history of electricity, and yet, no section of the country is richer in individual characteristics and conditions which place the development and use of electric power amid more picturesque or unique surroundings.

To the visitor familiar with the methods and customs in other sections of the country, there is a constant source of interest and wonderment, divided between the accomplishment here and the ever-changing, but never-ending variety of scenic beauty and topographical advantage which nature has provided as a fit setting. Nowhere would it be possible to see the art of power development better exemplified as a logical result of natural surroundings, and nowhere can be seen to better advantage the upbuilding of a comparatively new country, into a great metropolitan district, as the result of the introduction and aid of electricity.

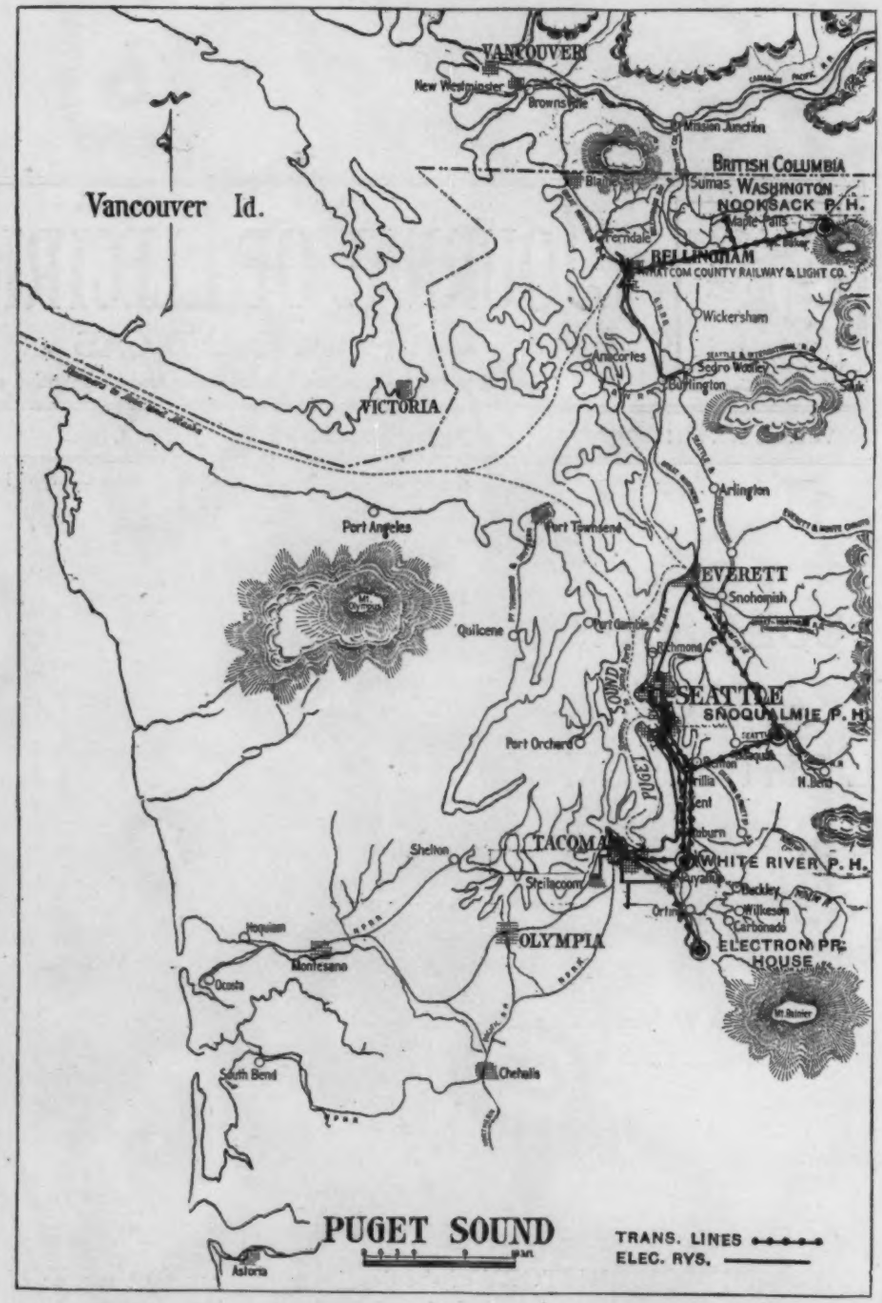
By far the greater part of the population of Western Washington is on the eastern and southern shores of Puget Sound and it is this district in which are the principal tide water cities which are served by the great electrical distribution network about to be described.

As in other centers of population the growth here of this system has been the welding together of many

smaller enterprises, each reaching out as the art advanced and as its sphere of usefulness increased, until the gaps were covered and a logical unit has been created in the Puget Sound Traction, Light and Power Company.

Far reaching results have been accomplished by the great managerial machine that the Stone & Webster operating company represents, and the unity of purpose between this, the Engineering Corporation, and the various constituent parts is shown by the very evident care exhibited in the selection of a high class of men, whose interests are clearly those dictated by a broad and generous public policy; the best grade of equipment and service, and the apparent desire to maintain the finest standards.

The symbol of the triangle and triskelion, which may be seen on all the company's equipment, advertising and correspondence, is the emblem which has been adopted to exemplify these high aims. For the equilateral triangle stands for stability and can never rest on any but a stable foundation. This, then, represents the thorough organization of all parts and solid structures, both physically and commercially. The triskelion is an emblem of great antiquity and represents motion; the gathering and holding together of individual motions to co-ordinate and respond in unison about a common center. This symbolizes unceasing activity and continual advancement as a prime principle in a world development.



Map of Puget Sound Traction, Light & Power Company's Lines.

Market for Power.

The territory served by the Puget Sound Traction, Light and Power Company is one of enormous natural resources. The manufacture of cement on a large scale represents an important industry. Coal deposits are distributed throughout the district and the outlet is here provided for the products of a vast interior agricultural and fruit country. Its cities are the logical ports for the output from the Alaskan territory, and steamship lines to the Orient form the connecting link with the four transcontinental railways which terminate on Puget Sound.

The market for power is varied and covers the supply of electricity to many large industries. At all points large amounts of power are supplied for railway operation. This being a lumbering country, power is supplied to mills of all descriptions. At Everett the Great Northern Railway shops require 575 h.p. and at Seattle, Tacoma and Auburn, power is also supplied for a like purpose. At Seattle are large flouring mills and all other industries incident to a metropolitan city. At Tacoma a block of 3,000 h.p. is supplied to a smelter.

Practically all of the 2300-volt distributing lines are two-phase and all of the lighting is done from these circuits, except in the downtown commercial district in Seattle, where a low voltage, Edison three-wire direct current system is in extensive use.

HYDRAULIC POWER PLANTS.

Snoqualmie P. H. No. 2.

THE Nooksack Falls plant is situated on the Nooksack River, where a fall of 165 ft. is obtained. A timber crib diverting dam delivers the flow into a concrete intake in which are gates. After passing through a tunnel 300 ft. long, having a section 5 ft. x 5 ft., excavated through rock and timber lined, the water passes through sluice gates into a timber forebay. There are two pipe lines; one is of riveted sheet steel 47 in. diameter and 1300 ft. long; the other is a wood stave pipe having a diameter of 44 in. The pipes approach each other on a curve and join in a steel "Y" manifold fitting and from this receiver are the various outlets to the waterwheels.

The powerhouse is a concrete structure 57½ ft. x 40½ ft., having two temporary ends for future extension. The roof is carried on Howe steel trusses.

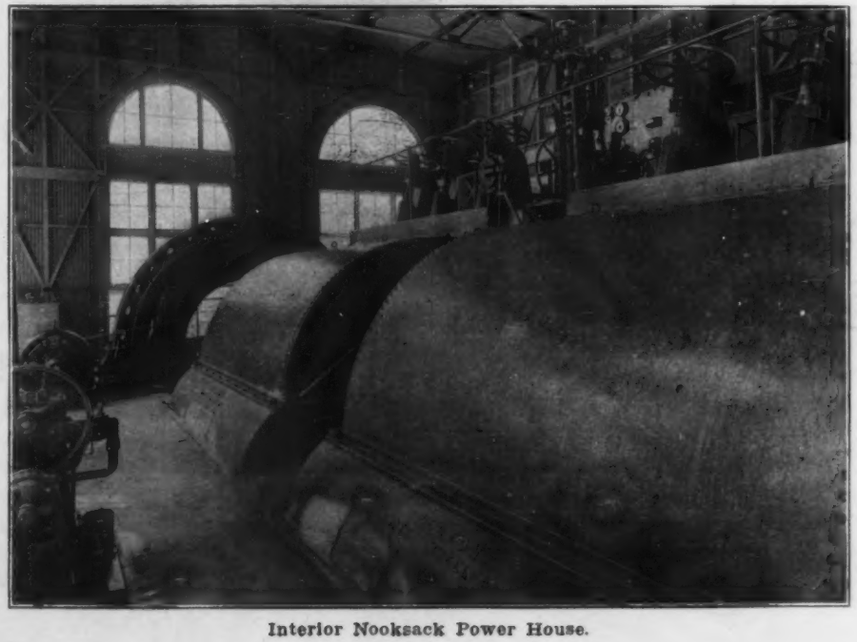
The generator is a Westinghouse 1500 kw. revolving field, delivering three-phase, 60 cycle current at a potential of 2200 volts. It is connected through a flexible coupling to a Pelton tangential water wheel equipped with six runners. Each runner is supplied with two nozzles, the upper nozzle on each wheel being needle regulating and the lower plain, supplied with deflecting hoods. The maximum capacity of the waterwheel is 3200 h.p. and the speed of the unit 200 r.p.m.. The exciter is a Westinghouse 45 kw., 125 volt d.c. generator, belted to the generator shaft.

The switchboard is in three panels and is Westinghouse standard equipment. There are three 500 kw. Westinghouse, oil immersed, air cooled raising transformers, the primaries wound for 2200 volts delta and the secondaries for 28,000 volts star. These transformers will be soon replaced by transformers to deliver 55,000 volts.

White River Plant is the newest and the largest of the power plants on this system and when the complete installation shall be completed will be the larg-

Intake for Nooksack Power House.

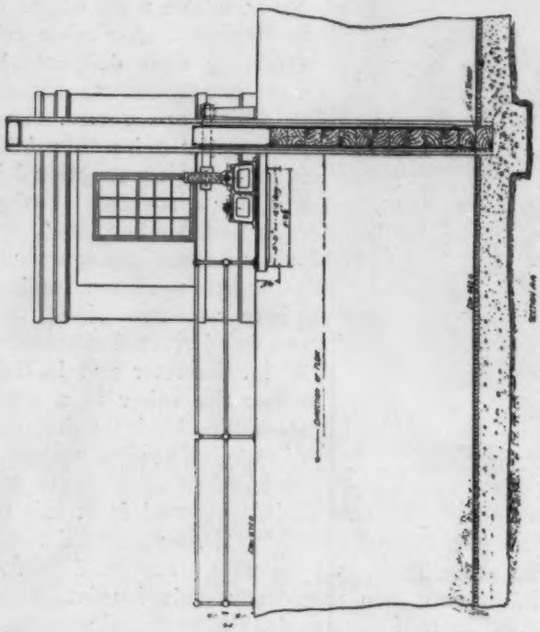
est plant in the Northwest. The development of the natural fall of the White River combined with the storage possibility of Lake Tapps has been in prospect for a number of years, but it was not until 1910 that this company started active development work. This installation is one of those which are a joy and inspiration to the engineer as it would seem that nature itself had purposely created the conditions with the eventual development of a large power plant in view. Almost everything is here provided for the working out of designs, both economical and safe. The White River flows in a north-westerly direction



Interior Nooksack Power House.

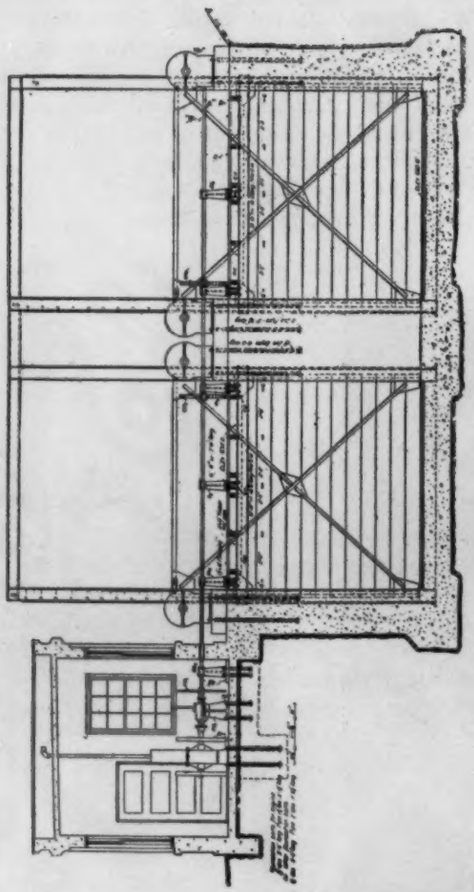
Nooksack Power House.

Gates and Operating House.

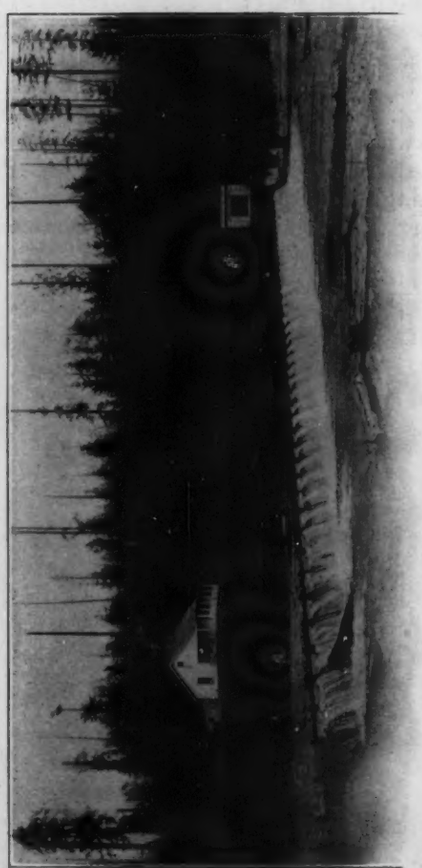


Longitudinal Cross Section.

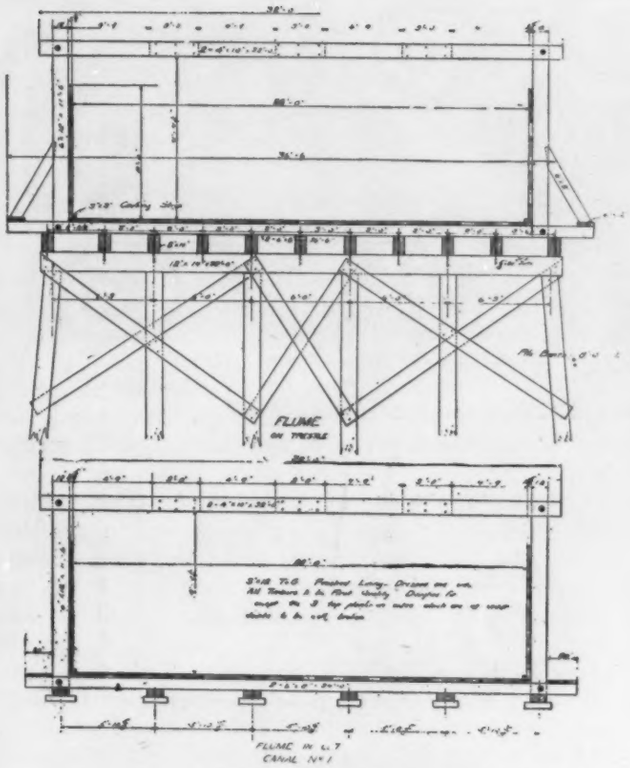
Intake of White River System.



Transverse Cross Section.



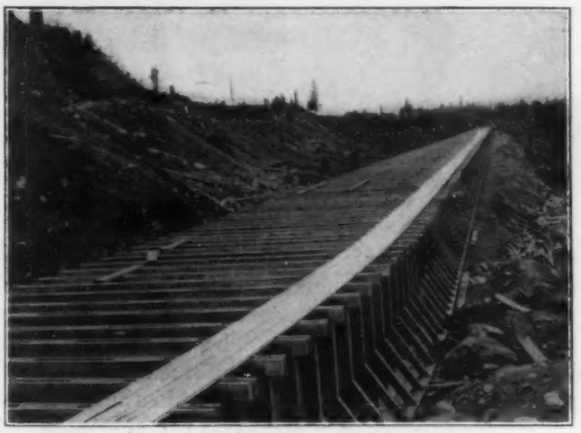
Dam.



Typical Flume Sections.

through the foothills of the Cascade range until the valley is reached, where it joins the Dahomish and is discharged into Puget Sound at Seattle. A large minimum flow, an extremely simple diversion, a high more or less level plateau, south of the river, terminating precipitously at the edge of the valley, a natural lake in this plateau with the possibility of greatly increasing its area and volume, a safe grade for the pipe lines and finally a powerhouse location on the main county highway, on three transcontinental railroads and between the two principal seaport cities of the state in a district where the older power lines were brought to get their market. Full justice has, however, been done in developing this wonderful site, for it would be difficult to find a system and plant of more economical or logical and yet simple design, showing throughout the careful thought in the design of details and the thorough understanding of all the conditions, local and general to be encountered. The construction work and finish is in keeping with the merit of design and the system is well worth the study of the engineer and operator.

Engineering interest commences at the intake dam, which is quite out of the ordinary for a river of this kind. The river, at the point of diversion, is fairly straight with a flat bed of the native cemented gravel. In order to give the necessary depth for the diversion a low dam only was required. Ordinary high water can be readily handled, but an ingenious method was necessary to prevent damage from flood. A trench was cut across the river and in this cut a slab of concrete was placed. Upon this foundation a timber crib dam was erected to a height of three feet. The top of the dam was finished with a flat crest, both the up-stream and down-stream faces being sloped, the former about two horizontal to one vertical, while the latter face was built one to one. The crest has an elevation two feet above the intake sill. Near the down-stream edge of the crest is a row of cast iron socket footings securely fastened flush with and to



Flume on White River Canal System.

the crib work, which is in turn bolted to the concrete foundation. In these sockets are fitted vertical timber posts 4 ft. high made of two 3 in. x 8 in. timbers bolted together. Near the upper end of the posts is an eye-bolt and hooked into the eye-bolt and extending toward the up-stream face, in an inclined position, is a ⅝ in. iron rod, the lower end of which is hooked into a bolt fastened into the crest of the dam. Flash boards are placed against the up-stream side of the posts. The strain rods are carefully calibrated for strength, they being intended to break and thus let the posts and flashboards wash away when the pressure against them, due to a certain height of water flowing over them, is reached. This high water point does not occur often and if the dam is broken, thus relieving all strain, the loss is so small as to be negligible. The crib section is covered with 3 in. planks on the up-stream side.

The intake diverts at right angles from the river. The weir crest is of concrete and the side walls of the same material. The intake bay curves around until the direction of flow is nearly parallel with the

Flume in Earth Canal.

river. The 12 ft. x 12 ft. timber gates, separated by a concrete pier, control the entrance into the canal, the sides of the gates being lined with stone. The gates slide in 12 in. steel channels and are operated by an

Lake Tapps.

enclosed worm-gear at each end. These in turn are driven by pinions on a common shaft, each pair of pinions sliding out of gear when it is desired to move one gate and not the other. The operating shaft extends into a 12 ft. x 12 ft.. reinforced concrete gate house having a concrete roof. Within the gate house is a Fairbanks-Morse 9 h.p. vertical single cylinder gasoline engine which operates the gates.

Beyond the gates the canal is paved with hard glacial boulders laid in cement to prevent scouring. This seems to be the solution of a difficult problem at this point as there is often sharp sand and cobbles which are carried by the water, the latter coming from glaciers on the side of Mt. Rainier.

The canal is now carried through an undulating country, passing through several artificial and natural basins and waterways and discharging into Lake Tapps. Beginning at the intake there is a flume for one mile. The ground surface for this flume was prepared in alignment and level as for a railroad except that it is wider. The flume has a clear width inside of 28 ft. and is boarded on the sides 8 ft. high, the depth of flow being 7 ft. There are two 4 in. x 12 in. stringers blocked together and spaced every four feet. The uprights are 6 in. x 12 in. timbers and the sills of the same size as the stringers. Longitudinal stringers are placed under the sills and these are supported on three rows of piles driven flush to the ground surface. The flow capacity of this flume is 2000 second feet.

Following the flume is a section of earth canal into which the water passes after traversing an artificial settling basin. This canal is two miles long. Steam shovels were used in its construction, there being two Marion No. 60, 1½ yd., one Marion No. 20, 1 yd, two Vulcan 1½ yd., and one Marion No. 35, ¾ yd. shovels. There is then a section of earth canal which is lined with a flume which is purposely not watertight. There are three rows of piles, two at the sides of the flume and extending to its top and to these are fastened the sideboards. The third row is down the middle and on them is a line of stringers on which the sills are supported. A sharp change in grade is shown in the view of this flume. The flow now enters an artificial basin of about 12 acres and then follows a natural waterway for two miles, discharging into Church Lake, a natural body of water two miles long and a half mile wide. From here it empties into an earth canal and natural channel 1500 ft. long which carries the water into Lake Tapps.

Lake Tapps is an irregular natural body of water surrounded by forests. In order to increase its capacity it was necessary to close many gulches or ravines through which the lake would have an outlet if

Earth Canal on White River System.

A Dam in Lake Tapps.

the original surface were raised. The closing of these ravines has been accomplished by the extensive series of earthen dams which have been erected, this line of dams extending at intervals along the north side of the hydraulic system, forming the different settling basins along the line of canal. These dams are formed of the natural gravel soil and are of various heights and lengths. Excavation work at the spoil pits was done with steam shovels loading onto cars. Track was laid on trestles at the dam sites from which the material was dumped to form the dams.

Near the lower end of the lake a complete electrically driven sawmill was erected with a capacity of 90,000 bd. ft. per day, to supply the timber necessary for the work.

The power plant intake was necessarily placed some distance from the lake, due to the ground con-

Tunnel from Intake Chamber.

tour and a connection between these points was made by dredging a canal, 50 ft. wide at the bottom and 1800 ft. long. This excavation required the removal of 600,000 cubic yards of material. It is lined with a submerged timber flume.

The slope down which the pressure pipes are laid has an anticline toward the lake and against this the intake is placed. This is of concrete with a pair of circular wing walls, forming a semi-circular entrance to the gates. Across the front ends of the wing walls is a series of 6 vertical steel-bar screens and placed in front of the screens are rakes which may be hoisted by ½ in. steel wire ropes. Above the screens, protected by a canopy, is a countershaft on which are mounted drums equipped with friction clutches and on these drums the hoisting ropes are wound to raise the rake. The countershaft is operated by a 10 h.p. General Electric induction motor. Water, after passing the screens, goes through a 12 ft. x 12 ft. sluice gate, similar to the intake gates into a tunnel. This gate is raised and lowered by two stems which are operated by a 25 h.p. variable speed induction motor and near which is a switchboard control panel. There is also a 24 in. hand-operated by-pass gate. The gate mechanism is enclosed in a reinforced concrete house 18 ft. x 18 ft. x 18 ft. high.

The tunnel is circular in section, 12 ft. in diameter. It is lined with concrete heavily reinforced with twisted bars and old railroad iron. The length is 2850 ft., and the grade 4 ft. per 1000 ft. Midway of its length is a 12 ft. circular vent and at the ground surface is covered with a square concrete structure, 5 ft. high, the sides of which are open but screened. A waste way is carried from this vent to take any water that may slop over. The tunnel ends in a concrete basin which is integral with the gate house and pressure pipe intake. Before passing through the pipe gates, the water again passes through vertical bar screens into the intake chamber. The rear wall of this is arranged in a segment of a circle, the three pipe entrances being 60 degrees apart. Each pipe opening is controlled by a Coffin sluice gate and mounted above the gate on the floor of the gate house are the operating stands,

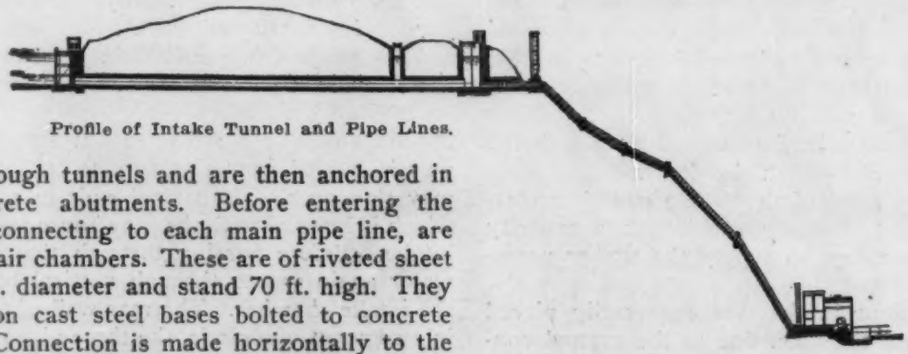
Tunnel Intake.

Tunnel Overflow.

equipped with a two-speed gearing and driven in each case by a 25 h.p. variable speed induction motor. Here is a 3-panel control board, the control being either from this point or from the switchboard in the power-house. A limit switch is mounted on the gate stand and the position of the gate is indicated by lamps at the power house. The gate house is a reinforced concrete building 18 ft. x 36 ft. and is provided with a 12 in. I beam over each stand for a chainblock hoist.

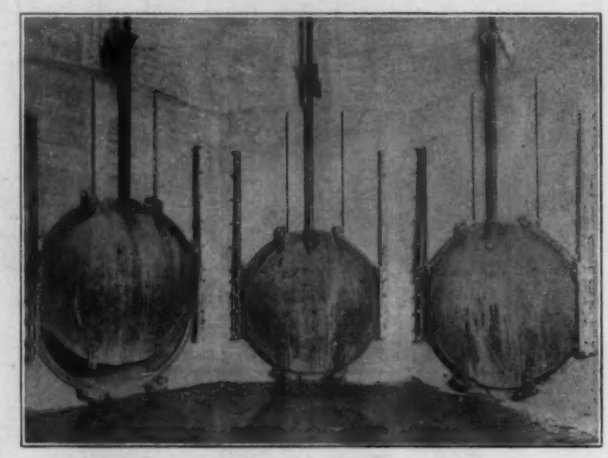
The pressure pipes after leaving this intake, pass through egg-shaped concrete lined tunnels for a distance of 200 ft. and then are laid in trenches which are backfilled, leaving the pipes buried, to the power house. There are at present installed but two pipe lines, provision at the intake being made for a third. Near the top are the two standpipes of riveted sheet steel. These are 6 ft. in diameter and 60 ft. high. Just before the standpipes are reached, a 24-in. outlet is taken from the upper side of each pipe. These are fitted with gate valves and connect to a horizontal manifold pipe of the same diameter which, continuing to one side, supplies the exciter pipe line through a gate valve.

The main pipe lines have a diameter at the top of 8 ft. and at the bottom a diamter of 6 ft. 6 in. The total length is 2141 ft. The exciter pipe is 24 in. diameter tapering to 20 in. In the final 400 ft. the pipes pass through tunnels and are then anchored in massive concrete abutments. Before entering the power house connecting to each main pipe line, are two standpipe air chambers. These are of riveted sheet steel, 6 ft. 6 in. diameter and stand 70 ft. high. They are mounted on cast steel bases bolted to concrete foundations. Connection is made horizontally to the pipe line through a 24 in. fitting in which is a gate valve. Where this fitting joins the standpipe is a valve actuated by a ball float. The valve shaft is brought outside through a gland and has a lever and counterweight. This is for the purpose of automatically closing the valve when the water within raises above a certain point. Compressed air above this water level is maintained by a large motor-driven compressor in the basement of the power house. These air chambers act as elastic cushions to compensate for the shock caused in the pipes by the sudden change in velocity of the flow, due to regulation of the waterwheels.

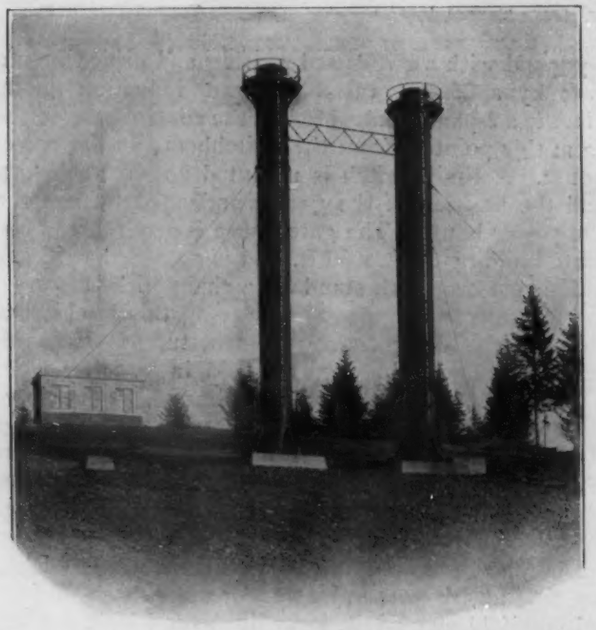


Profile of Intake Tunnel and Pipe Lines.

The building is of reinforced concrete throughout, for walls, columns and roof, the latter being supported on Howe steel trusses, and having a monitor roof along the center line. It is arranged on four general levels, basement, with four separate compartments containing auxiliaries, main floor on which are mounted generating units, transformers and generator busses, a mezzanine floor containing switchboard generator circuit-breakers, offices, lavatories, and store rooms and a high tension floor containing high tension switches and apparatus. The entire arrangement is simple and logical for effective operation. The finish, inside and out is light and plain, care being taken to give pleasing proportions in the design, the entire effect being satisfactory and not calculated to become monotonous to those who may be constantly associated with the plant. The columns divide the building into eight panels, while between the front and center row of columns is the main operating bay which extends from the main floor to the roof. The south end of the building has a temporary wall, as it is proposed to eventually make a further extension. The wall here, instead of marring the general appearance until the extension is made, as is so often the case when corrugated sheet iron is used, is made of metal lath and cement plaster, finished to correspond with the general architectural scheme, this costing very little more than the more temporary arrangement.



Penstock Gates at White River Forebay.

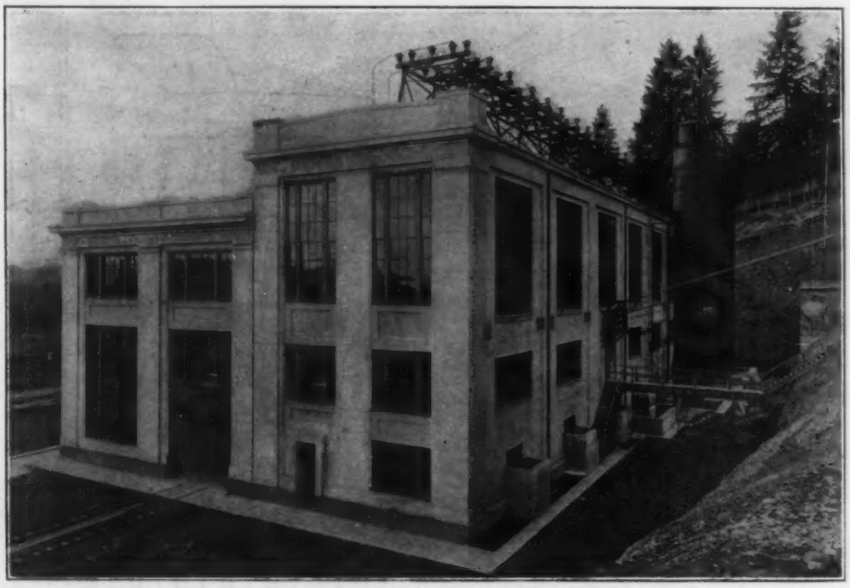


Penstock Gate House and Standpipes.

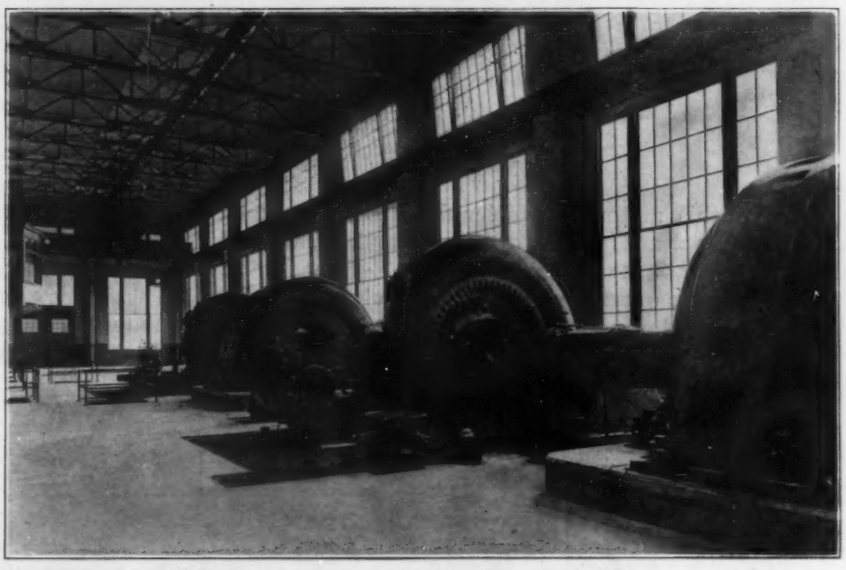
The main transformer compartments are placed back of the middle line of columns and extend vertically between the main floor and the high tension floor. These cells occupy the first three panel spaces. The exciters are placed under the switchboard mezzanine on the main floor level and occupy the next three transverse panels. The seventh and eighth panels have cells similar to those for the transformers, the former, however extending vertically only to the mezzanine floor. In this space are two sets of transformers for plant lighting and one set of power transformers for local distribution. The last space is at present vacant.

The four basement compartments are each reached by a flight of iron stairs from the main floor

level. The most northerly compartment is an oil room housing two steel tanks, 5 ft. 6 in. diameter by 13 ft. long, for containing No. 8 transformer oil; 2 vertical tanks 6 ft. diameter by 7 ft. high, for No. 6 bearing oil; one 12 in. oil filter of 20 chambers containing 30 sq. ft. of filtering area and having a capacity of 30 gal. per minute. Connecting this apparatus is a brass pipe rack equipped with 27 valves whereby all of the to the surrounding buildings, camp, etc. In the third section of the basement are placed the main generator rheostats. In the fourth section are three Allis-Chalmers, gear-oil-pumps, for supplying operating pressure to the governors, each driven by a 65 h.p., 220 volt, Allis-Chalmers induction motor. One of these oil pumps is also driven by an Allis-Chalmers 70 h.p. tangential water wheel, hand operated, which is at-



White River Power House.

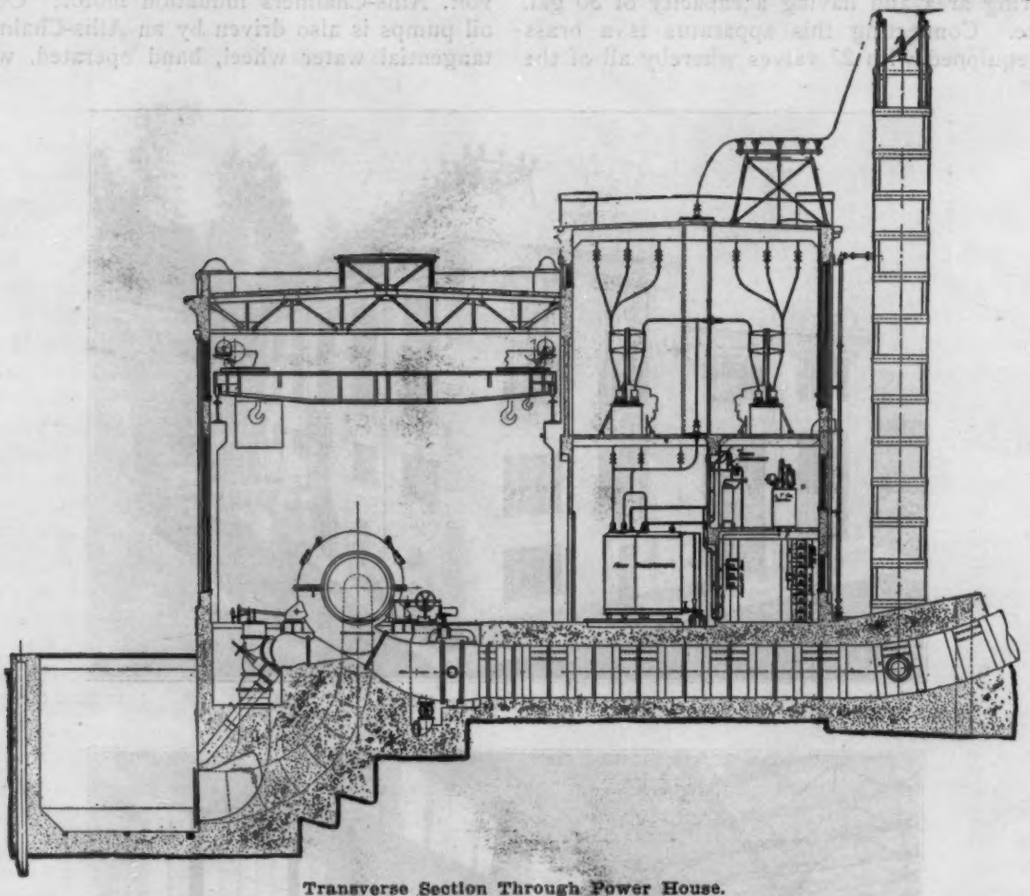


Main Generator Room of White River Power House.

various combinations may be made to circulate oil to and from the transformers for changing, filtering, filling, etc. A 7½ h.p. induction motor driving a centrifugal pump is the means of moving the oil, but connections are also provided for compressed air operation whenever necessary. In the second compartment is installed a two-cylinder Ingersoll-Rand compressor, driven by a 2200 volt, 150 h.p. form K, induction motor. Also a three-crank pump driven by a 10 h.p. Westinghouse induction motor for supplying water tached through a disconnecting clutch. Each pump will deliver 90 gal. per minute against a pressure of 400 lb. per sq. in. There is also a two-cylinder oil pump for furnishing oil to the machine bearings, driven by a 5 h.p. Westinghouse induction motor.

At present two main generating units are installed; the generators are General Electric type, A. T. B. form S, having a normal load capacity of 10,000 kw. The armatures are star-connected and deliver three-phase current at 6600 volts. The water wheel is

a Francis double flow turbine with scroll case. The unit has four bearings and operates at 360 r.p.m. A butterfly valve is introduced in the pressure pipe immediately before reaching the turbine and this is operated by a d.c. motor. On the floor back of the set

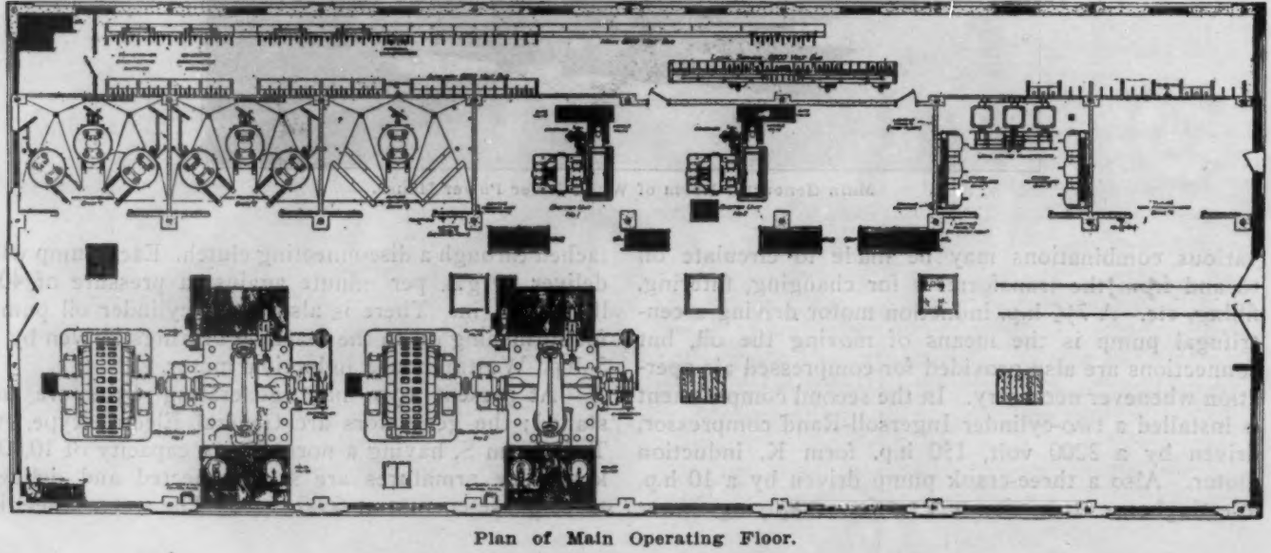


Transverse Section Through Power House.

is a panel switchboard for this motor with solenoid operated rheostat, switches, etc., and the control may be had at this point, at the motor or at the main switchboard. Allis-Chalmers governors operating with oil at a pressure of 300 lb., are mounted close to the turbine.

There are two d.c. exciters; the generator is General Electric, type M. D. C. form L, six poles with interpoles, 240 volts with a capacity of 225 kw. The waterwheel is Allis-Chalmers, having an overhanging runner mounted in a cast iron housing and equipped with a needle regulating nozzle operated by an Allis-Chalmers type O governor. It has a capcity of 500 h.p. and operates at 400 r.p.m.

The main transformers are single-phase, there being three in a cell which is open to the main bay, this opening being however smaller than the cell, 11 ft. wide by 15 ft. high. The floor of the cell is de-



Plan of Main Operating Floor.

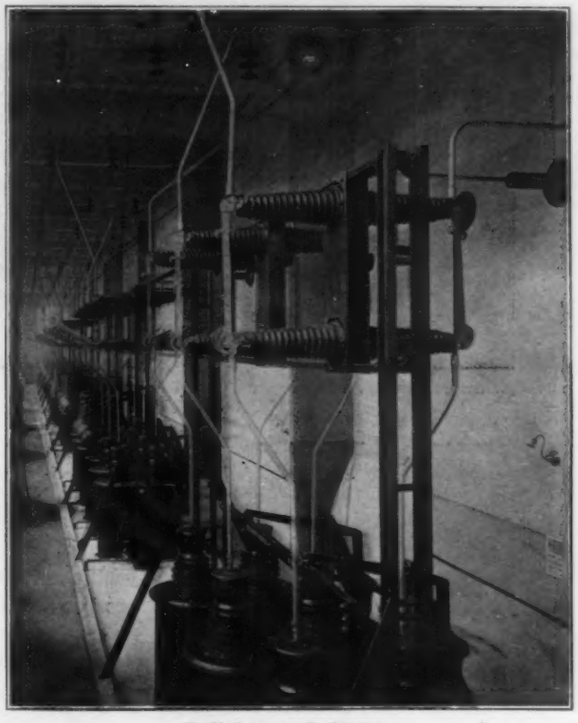
pressed 8 in. below the main floor and laid to drain to two points. The transformers are rated at 3333 kw. each and are wound for 6600 volts primary to 55,000 volts secondary, both sides being delta connected. They are General Electric type E. I. They are mounted on steel trucks with 6 in. cast iron wheels which in turn rest on a 3 ft. 6 in. track of 60 lb. rails. The tracks are laid, the center one being normal to the entrance, while the two others are placed at an angle so that in moving out, the transformers come out at the center of the entrance. The high tension terminals are wound fibre tubes with round fibre barriers.

The delta connections are made directly above the transformers and the high tension leads are supported from the ceiling of the cell on 8 sets of small three-part suspension insulators. The cell openings may be closed by double sliding doors of wood covered with tin plate and weighted open with cord and pulley.

In the rear of the transformers, mounted on the main floor level, are the disconnectors, double bus and meter transformers, all mounted in concrete cells, for the 6600 volt circuits. All circuit breakers are motor operated by remote control. The 6600 volt generator circuit breakers are type K-4 and mounted in concrete cells and are placed on the mezzanine floor in the rear of the transformers. Two sets of K-4 bus junction switches are mounted in the rear of the main switchboard. Near this set is a motor-generator battery charging set consisting of a three-phase, 220 volt motor, driving a 5 kw. d.c. generator. A Gould storage battery delivering current at 110 volts for operating the circuit-breaker motors and also a few emergency lights is installed in an adjoining room.

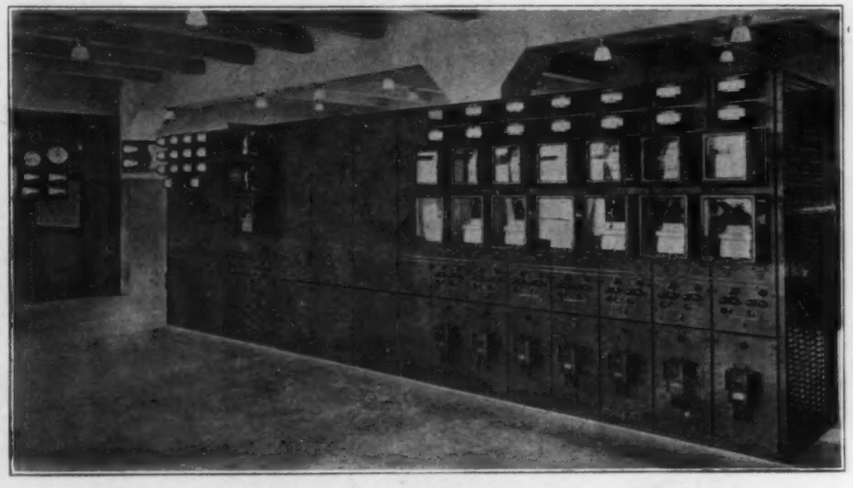
The upper floor is divided longitudinally by two parallel walls which are spaced 4 ft. apart. Over each longitudinal compartment extends a 55,000 volt bus line. In the forward compartment are 8 sets (3 single pole each) of K-15 oil circuit breakers connecting to eight transmission lines, and 2 sets of K-10 circuit breakers on the transformer leads. In the rear compartment are 7 sets of K-15 circuit breakers, with space for one more, to the transmission lines, and two K-10 circuit breakers to the transformers. One side of all of these circuit breakers connects to the bus over it. Disconnecting switches are provided on both sides of all oil switches.

The transformer leads, and outgoing lines are carried up between the longitudinal walls. The out-



Switches and Busses.

going lines pass through the roof of the building in roof insulators. A steel rack running the length of the building carries the line insulators for all of the transmission lines and Pacific Electric disconnecting switches on each line. These pass directly to the lightning arrester structures which are placed in the rear of the power house, a short distance up the hill. There are 8 lightning arrester houses; these are of concrete, 8 ft. x 16 ft. x 18 ft. high and contain aluminum cell arresters and a discharge recording device. The horn gaps are mounted on the roofs of these buildings.



Main Switchboard at White River Power House.

Typical Steel and Wood Tower Transmission Line Construction.

All high tension wiring in the building and on the lightning arrester structures consists of 1 in. galvanized iron pipe finished with bronze paint. This is not only a serviceable arrangement, but it is strong and rigid and low in cost.

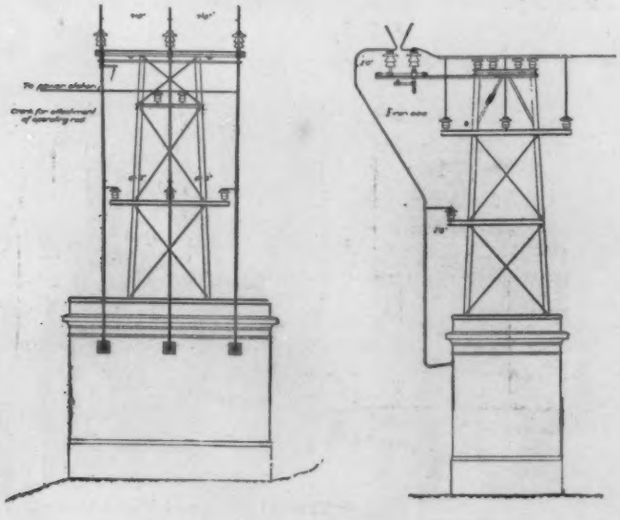
Lightning Arrester Houses and Transmission Lines.

Five telephone circuits are brought to the rear of the powerhouse, being protected by telephone transformers and fuses.

The switchboard gallery extends in an arching balcony into the main bay and is enclosed with windows; it occupies a space 40 ft. x 50 ft. The switchboard is of black slate in three parts. The main board, which controls the main units and lines, sets back from the balcony about 18 ft. and is parallel to it. The other sections are at right angles and are set across either end.

The north end board has three panels and two swinging arms, two controlling the exciters, the third containing a T. A. voltage regulator, while the arms carry instruments, a clock and a synchronizer.

The main switchboard has fifteen panels; two panels controlling generator and transformer remote control switches; one panel equipped with three graphic curve drawing instruments; seven panels with wiring diagram and remote control for the transmission circuits; five blank panels for future use. Time limit relays are installed on all outgoing circuits as well as integrating wattmeters.

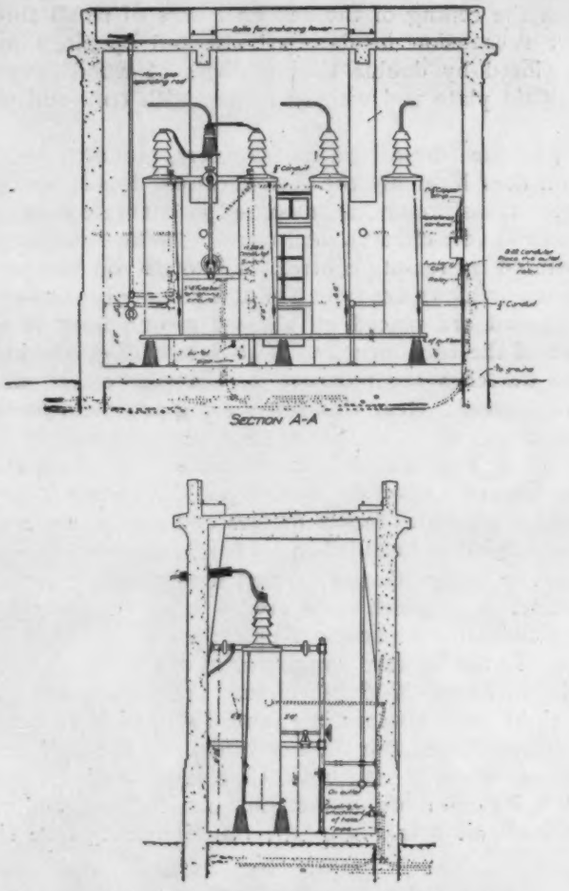


South Elevation East Elevation

Elevations of Lightning Arrester Houses.

The south end swithboard has five panels controlling consecutively, storage-battery, lighting, pressure gauges on governor system and on pipes and remote motor control.

Electron Power Plant derives its water supply from and is situated on the east bank of the Puyallup River. This is one of the streams which finds its source in glaciers of the western slope of Mt. Rainier. The river, which has a rapid fall, flows through a deep wooded canyon. The situation of this plant is more nearly like that of many of the high head Pacific Coast installations. For the lover of nature, its lights and shades, its coloring and wonderful perspectives with Mt. Rainier with its awesome grandeur



Section A-A

Section B-B

Vertical Sections Through Lightning Arrester House.

for a background, this is indeed an ideal country. But for building and maintaining a power plant the esthetic features have shown themselves to be more or less impractical, for here there is not the natural preparation of site that was found at White River.

This plant, which was completed in 1904, was famous in its time as an example of modern high head design and has given faithful service, with the exception perhaps of the necessarily high depreciation expense of a mountain-side timber flume.

The intake from the river is an even more simple affair than that of the White River plant, it being a timber crib dam 200 ft. long and 5 ft. high across the river, giving the water sufficient depth for an entrance into the canal. The intake consists of 14

Cable Tramway.

Intake of Electron Flume.

openings set in a line parallel to the flow of the river on the east side and is 62 ft. wide. These openings may be closed by planks which slide into place being held by steel rails. A masonry bay is formed by carrying the wall around against the bank, the lower wall making a right angled turn to form with it an entrance for the canal. There is no sluice gate due to the frequent entrance of glacial boulders which are allowed to enter the canal to be discharged at a specially built gate.

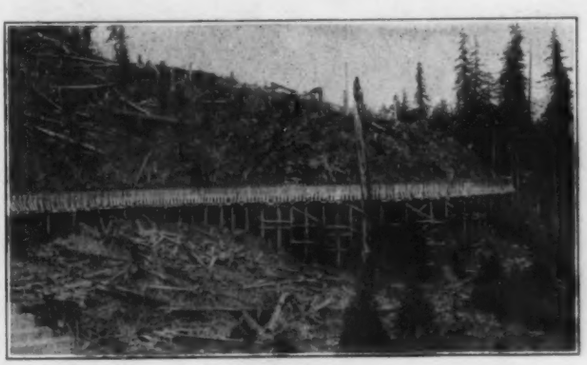
From this entrance the canal consists of timber flume and this follows the contour of the mountain side in a general way, sometimes almost on the ground, then again on high trestle, for a distance of ten miles, where it empties into a forebay reservoir.

The flume has a capacity of 360 second feet and carries 6 ft. 6 in. depth of water. The grade is 7 ft. per mile. Originally the flume was built to carry but 4 ft. of water, having five 12 in. planks for siding. Later three more planks were added and new sills and studs were placed between the original ones. The planks, or boxes, are 16 ft. long and there are 330 per mile. There are 12 spillways, near the entrance being the rock spillway with an enlarged section and a bar screen. A standard gauge 30 lb. steel track is laid on the top stringers and transportation for attendants and materials is thus accomplished by means of gasoline motor cars. Along the flume is a line of poles which carry, besides telephone wires, a three-wire, three-phase, 2200 volt, aluminum (equivalent to No. 4 copper), power circuit. Two double truck cars equipped with induction motor-driven electric hoists and one car with a steam rig are provided for rapid repair work on the flume. In operating the electric hoists, the supply wires are tapped to the power line at any point, transformers being mounted on the cars. A sawmill, electrically operated, situated near the upper end, supplies flume timber.

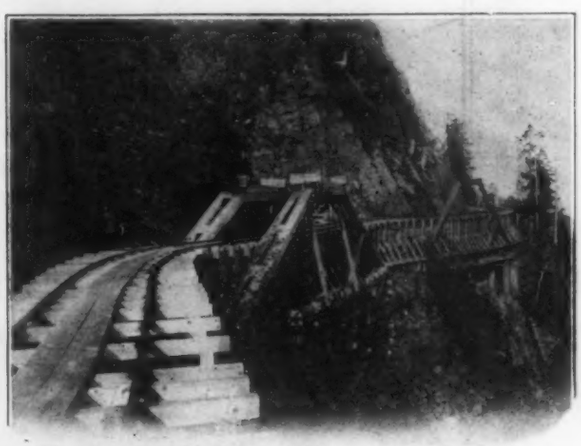
The forebay reservoir was made by throwing up earthen embankments on two sides. It covers an area of 10 acres and has a capacity of 7,000,000 gal.

The glacial silt carried by the flume, were provision not made for cleaning out at regular intervals, would soon fill the reservoir. A barge is provided on which is mounted an 8 in. sand pump having a rated capacity of 150 yd. solid matter per hour. This is belt driven by a 40 h.p. type CX, Westinghouse induction motor. Another belt from this motor also drives a 2 in. centrifugal pump for the submerged water jets. An articulated pipe mounted on pontoons discharges the silt from the pump over the reservoir bank.

The four pressure pipes, which at the top are wood stave construction, are carried through the reservoir bank to the intake heading, which is placed in the reservoir, about 100 ft. from the crest of the bank



Electron Flume.



Difficult Construction on Electron Flume.

Forebay Reservoir at Electron, Showing Suction Dredge.

The intake is of massive concrete and contains four sloping bar screens of 1-in. separation. Behind the screens are the screw stem sluice gates, hand operated with bevel gears. There is one small gate for the exciter supply pipe. A Dibble reservoir gauge is installed on the intake.

Wood stave pipes are carried through the reservoir embankment where they join with sheet steel riveted pipes, these being anchored in a concrete retaining wall. Each pipe has an open standpipe. The pipes now take direct plunge down the hillside, being anchored every few feet in heavy concrete abutments. Before entering the power house the pipes are heavily anchored in concrete blocks. The diameter of the main pipes at the top is 48 in. and the thickness ¼ in. and at the bottom 36 in. with a thickness of ¾ in. The wood stave pipes have a diameter of 48 in. The hydrostatic head on this plant is 872 ft.

The pipes are carried under the main floor of the powerhouse, each pipe dividing in a cast steel Y fitting, and each branch connecting directly to each of the two deflecting needle nozzles of each generating unit. The exciter pipe likewise divides each branch supplying the water wheel of the two exciter units.

The power house is built in two sections, of brick and concrete, the one section nearest the river containing the generating units and switchboard, and the other, built in several stories, due to the steepness of the hillside, the low and high tension switches and busses, the upper story being of timber and corrugated galvanized sheet iron.

The four main generating units are rated at 3500 kw; the armatures are Y connected and deliver 2300 volts and operate at 225 r.p.m. There are two Pelton waterwheel runners mounted in separate combination cast iron and sheet steel housings overhung at either end of the generator shaft. The single deflecting needle nozzles on each wheel are operated together by a Lombard type L governor. The nozzle needles are actuated from the switchboard by a 5 h.p. d.c. series motor. The main gate valves in each branch are operated by screw and worm gear by a 3 h.p., d.c. series motor. Oil under pressure for the governors is supplied by a Lombard triplex pump driven by a 6 h.p. series d.c. motor.

There are two 3-bearing exciter sets, having Pel-

Electron Power Plant.

Main Generating Room
Electron Power House.

ton water wheel, induction motor and d.c. generator. The motor is General Electric, 200 h.p., 2080 volts, three-phase. The generator is of same make, 125 volt and rated at 150 kw. The speed is 600 r.p.m.

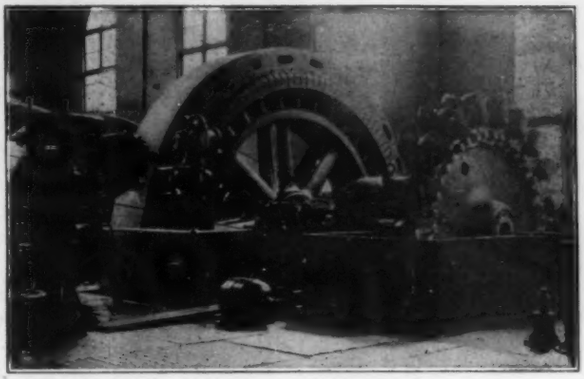
The switchboard is arranged in a semi-circle on a balcony at the far end of the building. It is of blue marble and has 17 panels, and is of a conventional type. There are four generator panels; two d.c. exciter panels; three panels on transformers with time limit relays; two transmission line panels; one T. A. voltage regulator panel; one panel with graphic recording instruments and reservoir gauge; and two local lighting panels.

The transformers are placed in cells back of the rear wall of the generating section; the openings to these cells being closed with steel Venetian doors. The transformers are mounted on wheels set on rails whereby they may be moved out into the main room to be handled by the traveling crane. The three sets of three single-phase transformers are each rated at 2333 kw., they are water cooled and have a voltage ratio of 2300 to 55,000 volts, delta connected on both sides. Between the rear wall of the lower building and the front wall of the rear struc- is a space utilized to carry the high tension wiring. The transformer cells include this space but also extend under the first floor of the rear building.

There is a 50-ton electrically operated traveling crane with a 5-ton auxiliary. On the first floor of the rear or switch building are the 2300 volt disconnecting switches; there is also a set of oil circuit breakers for local 2300 volt circuits and a potential reguator.

On the second floor are mounted 2300 volt bus lines against both the front and rear walls, separated by concrete compartments. Down the center of this floor are the 2300 volt oil circuit breakers mounted in brick compartments. There are three type H-9 sets on transformers and four sets of type H-3 sets on the generators, and two sets for the induction motors on the exciters. Connections to these switches are made from the floor below and they are all remote control, motor operated.

On the third floor are the high tension disconnecting switches mounted on timber racks, five sets in front and seven in the rear. The leads from the transformers are brought up through the space between the



Exposed Water Wheel Runner on Main Unit, Electron.

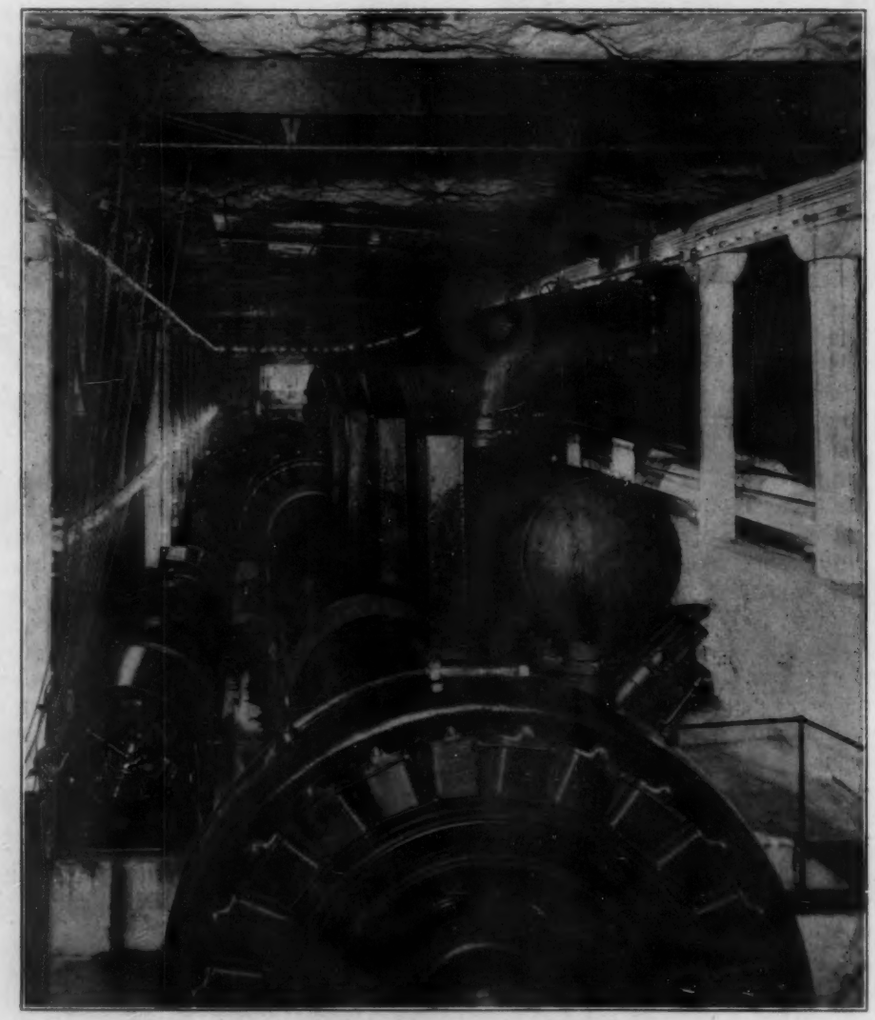
walls to this floor and then horizontally to the disconnectors. From these the lines are carried to the single high tension busses on the fourth floor. The high tension circuit breakers in five sets are type FE, style H-3 and are mounted in brick compartments on this floor and the lines are carried underneath to them from the disconnectors. There are two outgoing lines, these dropping back from the disconnectors to the horizontal position of the transformer leads, but ascend into and are led out through gables on the roof.

The Snoqualmie Falls Plant, the pioneer installation for long distance transmission in the Northwest, has helped to form the comparatively short but kalidescopic history of the transmission of the power of water falls to power consuming markets. The visitor to the cavern power house is reminded of the year when this unique and altogether spectacular installation was completed, by a large sign bearing the numerals "1898" in incandescent lamps. Snoqualmie Falls is in the foothills on the western slope of the Cascade mountains, 25 miles due east from Seattle, at a point where the Snoqualmie River after running quietly and almost level for a number of miles, suddenly comes to an abrupt falling away of the hills and plunges in a vertical fall of 270 ft. After a half-mile or so of riffles it again resumes its smooth course. That the fall itself is spectacular and beautiful goes without saying and the whole setting of rock precipices and wooded slopes is one of Nature's masterpieces. There are two generating plants, the second known as No. 2 having been completed within the last year.

Snoqualmie Falls, Dam, No. 1 and No. 2 Intake.

In designating the first plant it was thought that it would be impossible to erect a plant below the falls which would not be more or less affected by the dense spray which rises from the base of the falls. For this reason the power house was placed in a cavern hollowed out of the solid rock, directly under the south bank of the river and back from the brink of the falls a distance of 100 ft. This cavern is 200 ft. long, 30 ft. high and 40 ft. wide. A tail race was excavated the length of the cavern and extending as a tunnel a distance of 450 ft. until it could discharge into the river. This tail race is 24 ft. high and 12 ft. wide. Near the up-stream end of the cavern is a vertical shaft 10 ft. x 27 ft. which reaches to the ground surface on the south bank of the river. Here a double forebay containing vertical bar screens and electrically operated headgates delivers water from the river into two riveted sheet steel vertical penstocks, each 7 ft. 6 in diameter These are placed on either side of the vertical shaft the space between them being occupied by an elevator operating between the ground level and the generating room in the cavern. This elevator is operated by a small tangential water wheel supplied by water from a separate pipe.

One of the penstocks, after reaching the cavern, turns at right angles and extends the length of the generating room, but resting upon a shelf cut into the side of the cavity. From this penstock are four horizontal outlets at right angles, which deliver the water into headers or manifolds and from each of the four manifolds, taken from the under side at right angles, are the feeder pipes, six to each generating unit. The four generating units thus supplied have Westinghouse 1500 kw., revolving armature, three-phase, 2000 volt generators, the sets being arranged, two right-handed and two left-handed, so that two generators are adjacent in the middle and a generator on each end. The generators are direct connected to Doble tangential water wheels. There are 6 runners in pairs in three cast iron housings. These are 45 in. diameter and water is supplied to each runner through two needle regulating nozzles. Type B Lombard governors, water operated, regulate the speed of each unit, which is 300 r.p.m.



Interior of Snoqualmie Falls Cavern Plant.

The two exciter units each have a 75 kw., 125 volt d.c. generator, operating at 460 r.p.m. direct driven by a Pelton water wheel enclosed in cast iron housing, and supplied with deflecting hood over the nozzle operated by a worm gear hand wheel.

At the upper end of the cavern is a more recent unit rated at 5000 kw. This is a Westinghouse, 2000 volt, three-phase generator driven at 300 r.p.m. by

a Platt Iron Works, scroll case, Francis turbine, equipped with a 66 in. single discharge runner. A Lombard type N governor controls this unit.

On a gallery above this unit is the switchboard and also a motor-generator exciter set, the generator being a Westinghouse 75 kw., 125 volt d.c. machine direct driven by a 110 h.p., 2000 volt induction motor of the same make, at a speed of 600 r.p.m.

Transformer House at Snoqualmie Falls.

The switchboard is in two rows on both sides of the gallery and is a Westinghouse equipment, with round dial instruments, having eleven vertical panels and three horizonal superimposed panels. Five panels control generators together with the three upper panels. Of the remaining, three are on transmission lines; one on local lighting; one has a Tirrill voltage regulator; one on switch control for power house No. 2. A blower driven by a 30 h.p. Westinghouse induction motor draws air from the tail race for ventilation, and at the top of the shaft is a similarly driven exhaust fan.

The transformer house for both power houses adjoins the cavern intake. It is a two-story brick building 60 ft. long and 40 ft. wide. On the ground floor, ranged along the south side are six Westinghouse 2500 kw., water cooled raising transformers in two banks. These have a primary winding for 2000 volts and a secondary of 55,000 volts, the lines to both sides being delta connected. On the opposite side are three General Electric 2917 kw. water cooled transformers supplied from No. 2 power house. These transformers have voltage ratios of 60,000/2,000-4,000-6,900 Y, but are operated in parallel with the first named banks. Running longitudinally and near either side wall of the building are two free galleries supported by steel columns, and on these are mounted the oil circuit breakers. Between the galleries and supported by them is a hand operated traveling "horse" crane. A high tension endless bus is carried all around the building above the switches and this is sectionalized at four points with disconnecting switches, so that two consecutive sections have a transformer oil circuit breaker connection to a bank of transformers, and also a similar connection to a transmission line; a third section has an oil circuit breaker transformer connection and the fourth an oil circuit breaker and line connection for the Everett line. On the No. 2 transformer feeders is a Westinghouse type G. A. oil circuit breaker solenoid-operated and controlled from power house No. 1. With it are mounted two series transformers and time limit relays. For the Everett line, a simlar circuit breaker set is provided. On the south side, two sets of transmission line circuit breakers are again similar, but the two sets of transformer circuit breakers were supplied by the Pacific Electric Company of San Francisco.

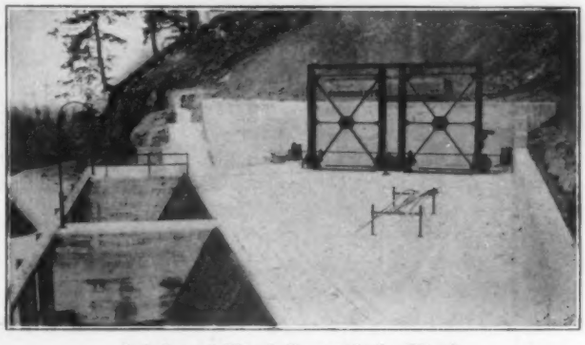
Placed on a heavy framework outside of the transformer house are General Electric aluminum electrolytic lightning arresters with horn gaps, connected to each outgoing 55,000 volt line.

In an adjacent building is an ample storeroom and a shop containing a shaper, machine lathe and drill press and two 3-crank plunger pumps driven by 10 h.p. induction motors for supplying water to the various buildings, cottages, etc.

The track of a branch of the Great Northern Railway passes the transformer house and a branch track is continued from the opposite bank of the river down an incline to power house No. 2. A car ferry consists of a scow controlled by cables, there being on either bank a track-apron which may be raised or lowered depending upon the height of the river and which will allow cars to be run on to the ferry.

The intake of the No. 2 plant is placed immediately above the low dam near the brink of the falls on the opposite side from that of No. 1. This intake is 85 ft. long between two concrete bulkheads with a 5 ft. wide concrete pier in the center. In each opening are four gates, closed with planks sliding between vertical channels and behind these are vertical bar screens having a 1 in. separation. The concrete walls converge to the mouth of the tunnel before which there are two rectangular gates 10 ft. wide sliding in channel guides and hand operated by rack gears. Each gate has at its center a small 21 in. gate for filling the tunnel when empty.

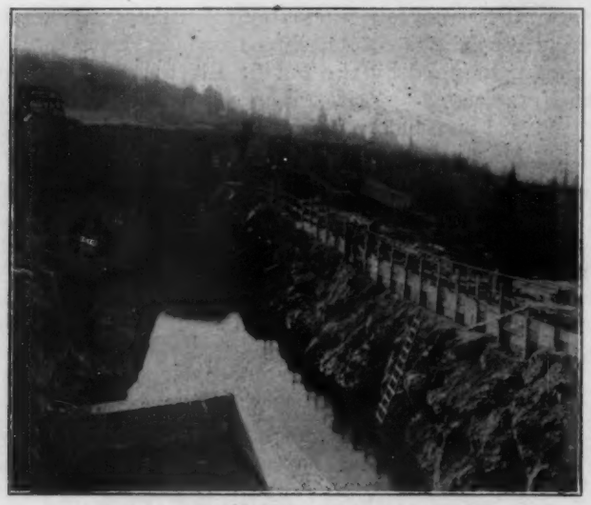
The tunnel has a length of 1035 ft. and is excavated in a curve through the spur which forms the north bank of the river extending some distance past the falls. It has a circular section, the excavation being made approximately 14 ft. in diameter. This was lined with concrete, leaving a finished diameter of 12 ft. It is calculated that with a loss of head at 5 ft., the



Intake of No. 2 Snoqualmie Plant.

tunnel will carry a flow of 1340 second feet. Water is delivered into an open canal, excavated in rock a distance of 220 ft. to the forebay of power house No. 2. This canal has a bottom width of 20 ft. and is unlined. At one point a notch has been cut through the spur for a spillway from this canal; this is 30 ft. wide and discharges into the river below the falls.

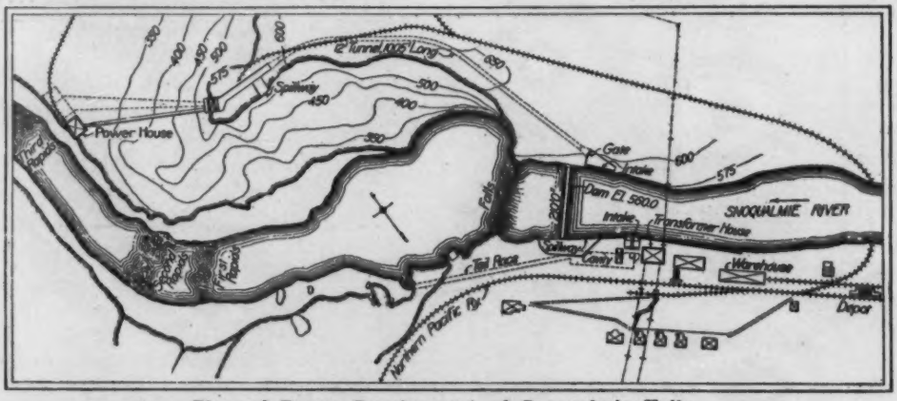
The forebay is of reinforced concrete and is set across the end of the canal, the water passing into it



Canal and Forebay of No. 2 Plant.

through the conventional steel screens set on a slight incline to the vertical.

Openings are provided for three pipes, it being proposed to eventually install three generating units, but one pipe now being installed. The flow is controlled by two Coffin sluice gates in tandem, each 8 ft. in diameter the first one being an emergency gate, with screw stem, manually operated; it is also provided with a trip arrangement, which, by opening the supporting nut, will allow the gate to drop by its own weight. This trip is operated by a wire run inside of a pipe from the power house. So far there has never been an occasion requiring the use of this emergency device. The other gate is operated from the power house by a 10 h.p. induction motor. There is a 24 in. by-pass gate, manually operated for filling the pipe line. The gate house is of reinforced concrete 50 ft. long and 15 ft. wide.



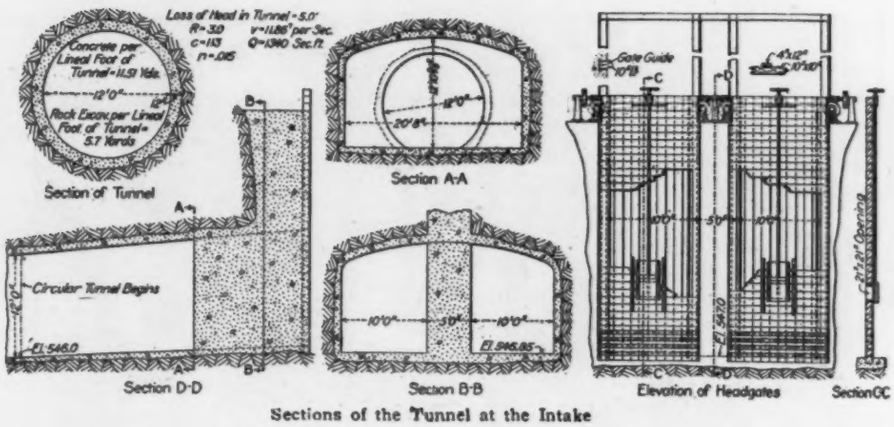
Plan of Power Development of Snoqualmie Falls.

Interior of Forebay Gate House of No. 2 Plant.

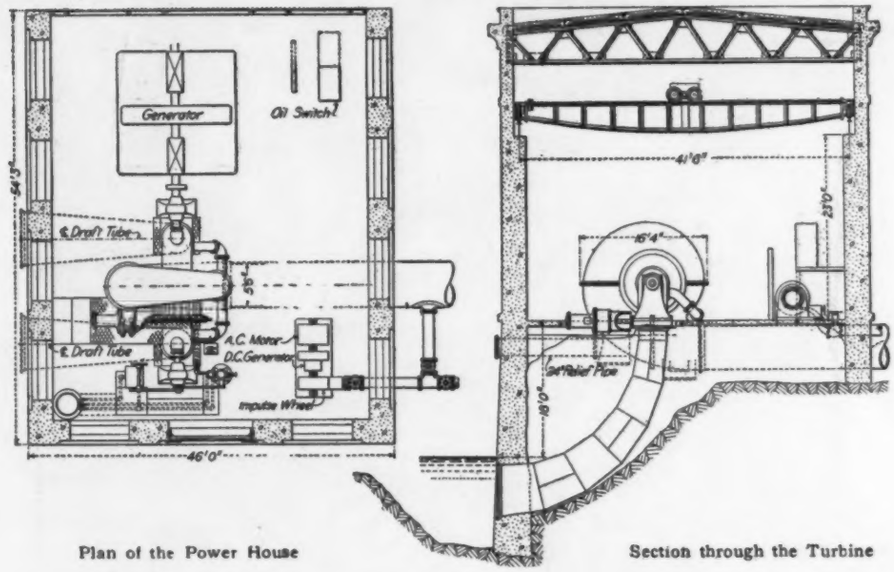
The pipe or penstock has a diameter of 7 ft., is of riveted sheet steel and varies in thickness from 3/8 in. at the top to 7/8 in. at the power house. It is supported and fastened to heavy concrete anchorages. The length of the pipe is 466 ft. The head is 255 ft.

The power house is of reinforced concrete of a modern and pleasing but conventional classic design. One end is left unfinished, a corrugated iron wall being used, and the future addition will continue the building from this point. Its position is close to the river and the draft tubes of the water wheel discharge directly into the river, they being carried low enough to be submerged at the period of lowest water. The building is 40 ft. wide and at present 50 ft. long. The roof is of concrete supported on Howe steel trusses, spaced 10 ft. apart; throughout its length a 50-ton, electrically driven Niles traveling crane operates.

The main generating unit consists of an 8,750 k.v.a. General Electric generator, the armature being Y connected to deliver 6900 volts, driven at 360 r.p.m. by an I. P. Morris double discharge, scroll case, single runner, Francis turbine. The hydrostatic head on this unit, including the draft, is 270 ft. The governor is of the double floating lever type built by the water wheel maker. A three-crank oil pump for actuating the governor is belted to the main shaft of the unit. On test this water wheel developed 12,500 h.p. with full gate opening and has a guaranteed efficiency of 82 per cent while delivering 8000 to 10,000 h.p.



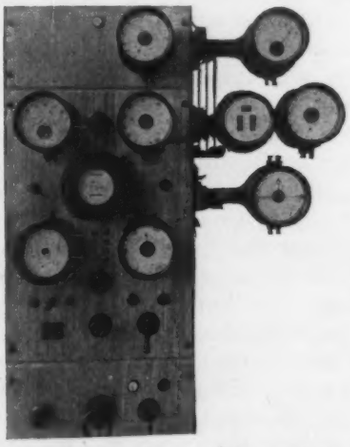
Sections of the Tunnel at the Intake



Plan of the Power House

Section through the Turbine

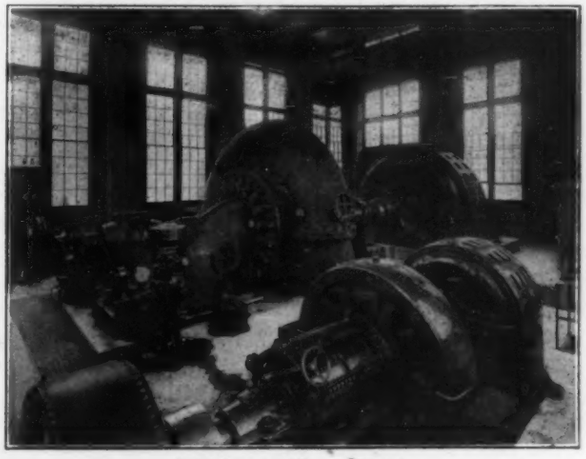
The exciter is a 200 kw. General Electric, 125 volt d.c. generator, driven on the one side by a 300 h.p. Doble tangential water wheel, supplied with a hand regulated needle nozzle; on the other end is connected



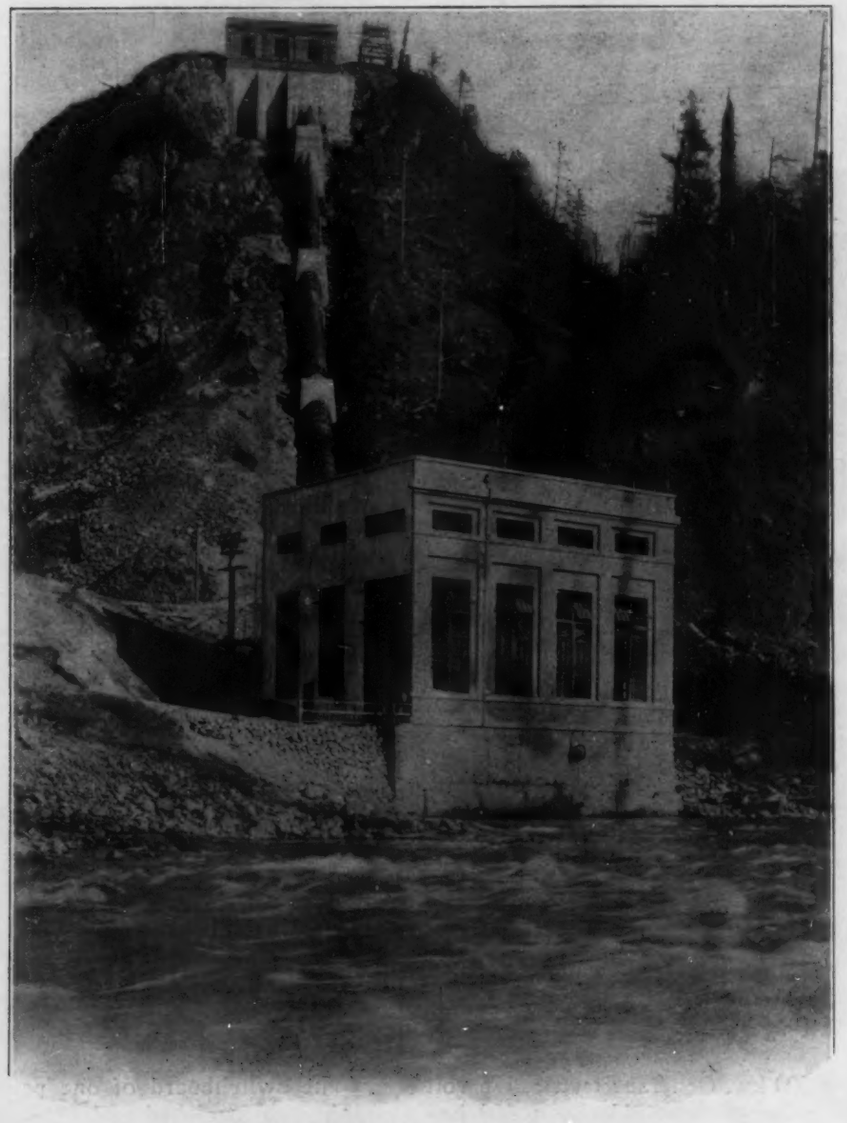
Switchboard at No. 2 Power House.

a 300 h.p. General Electric 2000 volt three-phase induction motor. This set has five bearings, there being but one on the outer side of the water wheel; it operates at 450 r.p.m.

The switchboard of one panel of blue Vermont marble was furnished and equipped by the Westinghouse company and is of a most recent type. It is mounted on a raised platform under which are the generator bus and disconnecting switches in concrete cells. In the basement are placed two type B Westinghouse oil circuit breakers, one on the generator circuit and one on the transformers supplying the ex-



Interior of No. 2 Plant.



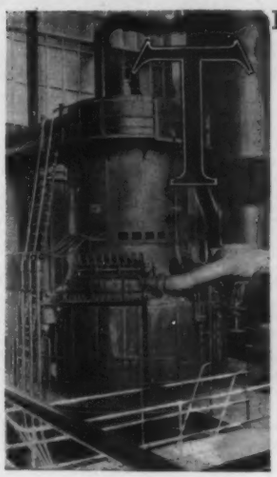
Snoqualmie No. 2 Plant.

citer motor. The latter are also mounted in the basement and consist of three General Electric 85 kw. transformers wound for 6900 to 2000 volts. At another part of the basement entered by stairs are a storeroom and a lavatory. These basements are the spaces formed between the machine foundations and the walls of the building. The 6900 volt, three-phase current from this power house is carried on two circuits on a pole line to the transformer house above the falls.

The watershed for the Snoqualmie system covers an area of about 400 square miles and extends in an easterly direction from the falls a distance of 25 miles to the ridge of the Cascade range. Much of this territory is in the Snoqualmie National Forest reserve and the altitude reaches to 7500 feet; it is heavily timbered. A number of lakes having areas of from one to three square miles form the headwaters of the Snoqualmie River and these discharge into three branches which meet about three miles above the falls. The rainfall varies as the elevation and increases from 60 inches at the falls to 120 inches at the highest altitude. Most of the precipitation occurs in the winter months. During the summer months the natural flow has a minimum value of 550 second ft. The total annual flow at the falls is about 1,800,000 acre-feet which is equivalent to an average precipitation over the watershed of 85 inches. It is proposed to utilize the possible storage facilities to conserve this flow and this will make possible a continuous discharge at the falls of 2500 second feet available for power purposes, which would generate 50,000 horsepower.

The watershed for the Electron plant covers an area of about 100 square miles, extending from the intake on the Puyallup River to the summit of Mt. Ranier. Above an elevation of 5000 ft., the canyons and ridges are covered with perpetual snow and ice and the contact of the moisture laden winds from off Puget Sound with this frozen covering is the cause of a heavy annual precipitation, estimated as high as 140 inches. These fields of ice and snow in the form of glaciers, of which there are five, ceaselessly moving down their respective ravines, are the source of the streams which go to make up the Puyallup River. The watershed is rough and very heavily timbered below the main mountain.

STEAM GENERATING PLANTS.



Turbo-Generator at Georgetown P. H.

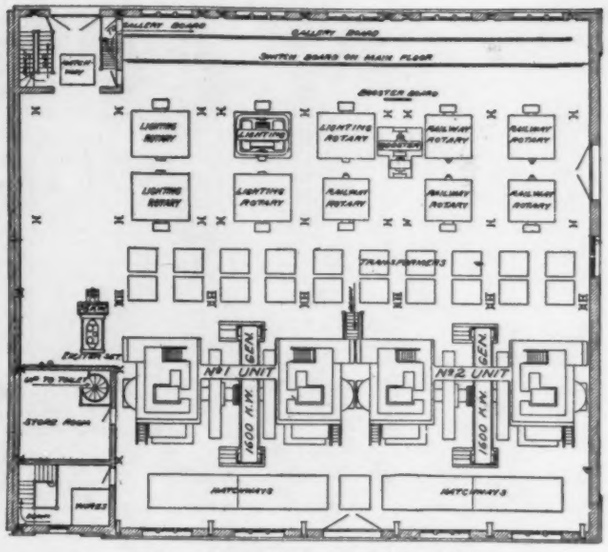
THERE are seven steam generating plants in the system, all of them, with one exception, having been originally central station plants, operating systems of their own without assistance from transmitted power. They are all now held as auxiliary or standby plants to be used only in case of failure of transmitted power. These plants are the Post Street, Georgetown and Diamond Ice Company power houses in Seattle, the central station power house at Everett, stations "A" and "B" at Tacoma, and York Street station a Bellingham.

Post Street Power House is a relic of the "days of steam" and was in its time a fine example of central station practice. It is now probably the busiest distributing point on the system, but not in the manner of a few years back when steam was the mainstay of the system. The station is situated within a block of the water front, where the transportation of fuel is an easy matter, in the most congested section of the lower commercial district. The building, equivalent in height to about five stories, is of pressed brick and covers about half a block. Starting at the top, the steel coal bunkers, having a storage capacity of 400 tons, are at the highest level. Coal is delivered into the bunkers by a bucket conveyor just outside of the building. This conveyor is loaded below the street level. Cars loaded with coal are dumped through an opening in the street into a pit in which is a coal breaker driven by a steam engine. The coal, after passing through the breaker, is loaded into the conveyor which is also operated by the engine.

The six Babcock & Wilcox boilers rated at 500 h.p. each, are on the upper floor. They are fed by Greene mechanical stokers which are driven from a shaft in turn operated by a General Electric 10 h.p. induction motor and also by a steam engine in case of emergency. Renton nut coal and screenings are used from a mine owned by the company. There are three Simmance-Abady CO_2 recorders, and draft gauges and recording thermometers on each boiler. Three Platt Iron Works high duty and one two-cylinder, induction, motor-driven pumps supply the boiler feed water. There are also two large steam driven feed pumps which get water from an artesian well, in case the city supply is inadequate.

The engine room is on the west side of the main floor. The two main engines are MacIntosh & Seymour vertical, double tandem compound units operating at 120 r.p.m.; between each pair of engines is a 1600 kw. two-phase 2300 volt alternating current generator. Over the engine units is a 50-ton electrically operated traveling crane.

An extensive steam heating system is operated

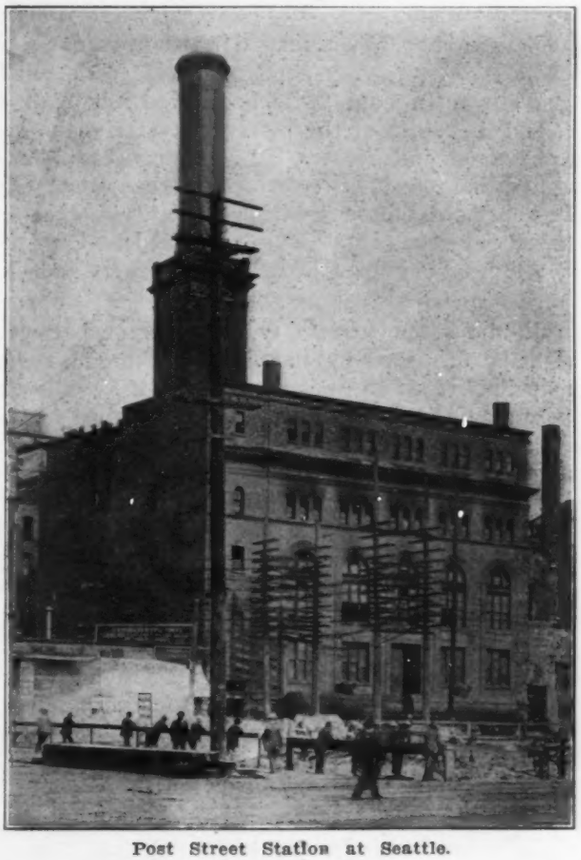


Plan of Post St. Station at Seattle.

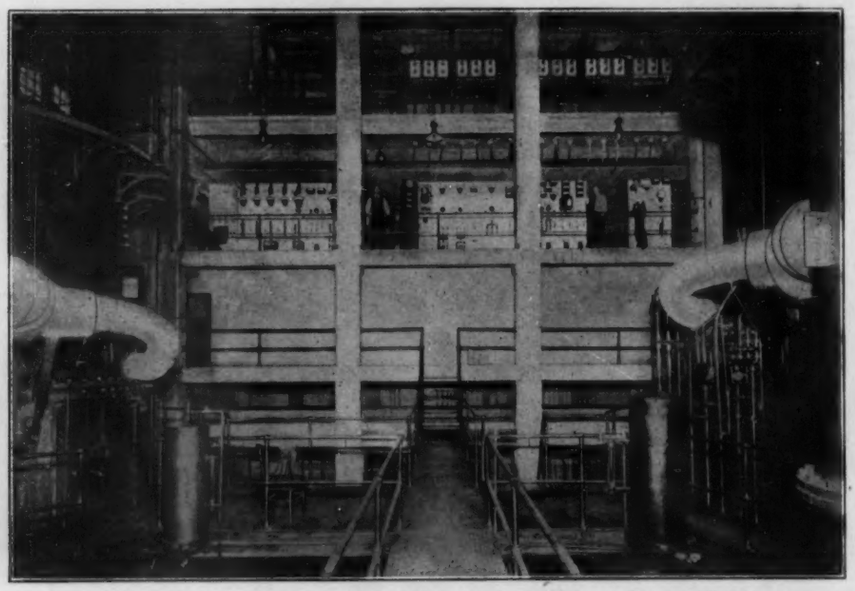
from this station and exhaust steam from the engines is fed into this system in accordance with the demand for heat. The station pressure on this system is 5 to 11 lb., the intention being to maintain a constant pressure at the farthest point of 2½ lb.

A 75 kw. 250 volt d.c. exciter operating at 290 r.p.m. is driven by a simple Ideal engine.

A large part of the main floor space is taken up with rotary converters, of which there are ten and one battery booster. Five of these rotaries are Westinghouse 500 kw., the a.c. side being three-phase, the d.c.



Post Street Station at Seattle.



View of Switchboard and Switches in Georgetown Power House.

Switchboard in Georgetown Power House.

side delivering 550 volts and the machine operating at 400 r.p.m. There is mounted on the end of the shaft a 40 h.p. induction starting motor. The remaining rotary converters operate at 360 r.p.m., deliver d.c. at 250 volts and are rated at 500 kw. A 20-ton traveling crane is provided for handling the rotaries and one of 10 tons capacity for transformers.

The battery booster or charging set is General Electric and is used for charging individual cells of the lighting battery. The motor is 50 h.p. and the delivered voltage 0-120 volts.

The switchboard is arranged in two rows, one above the other, on a gallery across one side of the building. The main floor switchboard controls both the a.c. and d.c. sides of the rotary converters, the storage batteries and booster, T. A. voltage regulator or engines and power circuits from other substations. The upper switchboard controls the Edison three-wire commercial circuits and the railway feeders, the equipment throughout being blue marble panels and General Electric standard instruments.

In the basement is a type H storage battery of 154 cells, furnished by the Electric Storage Battery Company. It is in two compartments of 77 cells each. There are 34 end cells on each side. The cells of this battery are made up of 69 plates each. It is used in connection with the Edison three-wire system, but only in case of emergency. It has a discharge rate of 4800 amperes. There are two end cell switches arranged to operate separately or in parallel, these, at the time of installation being said to be the largest switches of their kind in existence. A 24 in. wood-stave stack ventilates the battery room.

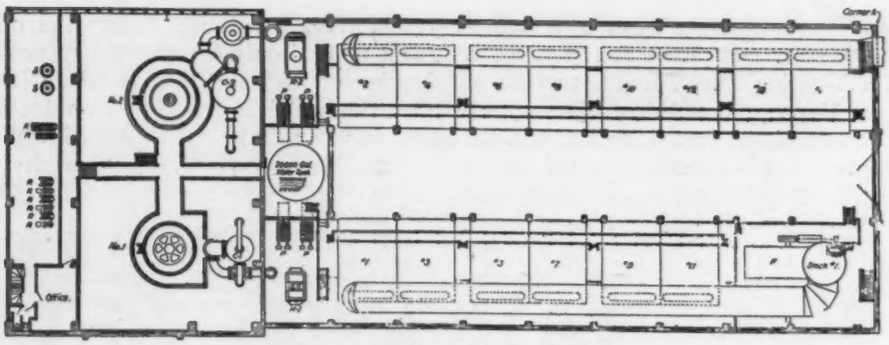
All feeders are carried from the basement into two manholes under the street, the one containing 64 ducts and the other 40. All feeders are in lead covered cables save a few Edison tubes still in use, which are gradually being eliminated. All lead sheaths whether for railway, Edison three-wire or 2300 volt service are grounded to the railway negatives.

Georegtown Power House is a modern steam plant, built only to supply power in large quantities to the various substations and used constantly under forced load until the advent of the White River hydraulic plant. This plant is situated on a large tract of ground adjoining the car repair shops at the southern extremity of the city of Seattle. The plant is in two sections, the one containing the boilers and the other the two turbine generating units, the whole covering a ground space 140 ft. long by 80 ft. wide. The building is a heavy reinforced concrete column and beam structure with heavy curtain walls of the same material. Detched from the boiler end and connected thereto by a flue is a reinforced concrete chimney.

The boilers are arranged in two parallel rows with a firing floor down the center. There are fourteen 460 h.p. Stirling water tube boilers with spaces for two additional on each side. It has been found possible to deliver 15,000 h.p. from the turbines deriving steam from the 14 boilers installed. Oil fuel is used which is purchased from the Standard Oil Company. Above the boilers is a heavy reinforced construction to provide for coal bunkers, as it was thought when this station was built that coal fuel might become an eventual necessity.

There are four Blake feed pumps with cylinders 14 in. x 9½ in. x 12 in.

The engine section contains the two Curtis vertical turbines, one being 8000 kw. and the other 3000 kw. Each turbine has an overload capacity of 50 per cent for a period of two hours. Barometric condensers are used. A 50-ton electrically operated Northern Engineering Company traveling crane operates across the building over the turbines. On the floor of the turbine room are two Weiss air pumps built by the Southwick Foundry & Machine Company. There are also two Southwick centrifugal circulating pumps driven by Porter Allen engines; two oil feed pumps; four pumps for auxiliaries and one motor driven pump; one air compressor oil filters, tanks, etc.



Plan of Georgetown Power House.

At the end of the turbine room is one 3-bearing motor-generator exciter; a 175 h.p. induction motor driving a 120 kw. 125 volt d.c. generator at a speed of 60 r.p.m.; one 75 kw. 125 volt d.c. exciter driven by a Porter-Allen simple engine at 270 r.p.m. For railway service there are two motor generator sets of 500 kw. capacity, these being the standard 514 r.p.m. sets used by the company, who put in interpoles after the sets had been in service four years. These sets supply power to the Seattle end of the Tacoma interurban system and the local street railway in the immediate district.

There are two 500 kw. General Electric water-cooled transformers reducing from 13,800 volts three-phase to 2300 volts two-phase for local power distribution, and two 100 kw. similar transformers for station service.

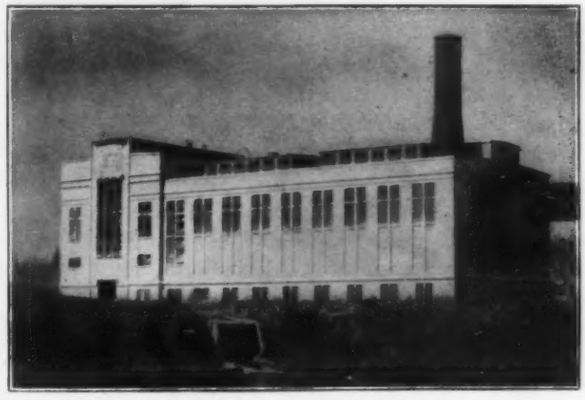
The switchboard is placed on a gallery over the motor-generators and transformers and consists of twenty-three blue marble panels. It is of standard General Electric type with horizontal edgewise and graphic recording instruments. There are two panels on the turbines; two on 13,800 volt feeders; one on 500 kw. transformers; three on 2300 volt power and lighting; five on exciters; one on T. A. voltage regulators; four on motor-generators, a.c. and d.c.; and five on railway feeders.

On a second gallery are placed nine sets of General Electric H-3 motor operated oil circuit breakers mounted in brick and concrete compartments. These control the outgoing 13,800 volt three-phase circuits. Of these there are two 0000 circuits, one of which goes to the Massachusetts Street substation and the other to the James Street substation; each of these feeders has a capacity of 6500 kw.

On the third gallery there are two General Electric K-4 oil circuit-breaker sets in compartments, caring for the railway motor-generator circuits. Two sets of aluminum cell lightning arresters on the outgoing lines complete the equipment of this station.

Cold air for ventilating the turbines is drawn through steel ducts from outside the building near the ground.

Diamond Ice steam plant situated in Seattle, close to the Union Street substation on the waterfront in the downtown commercial section, has recently been added to the system, originally being an isolated plant supplying its own network in the commercial section of the city, owned and operated by the Diamond Ice Company in connection with the ice-making system. The power equipment consists of three steam generating units, the first rated at 1000 kw. driven by a Reynolds cross compound Corliss engine, the other two being DeLaval steam turbo-generator units of 200 kw. each and delivering 250 volts into the Edison three-wire system. One 300 kw. and one 500 kw. rotary converter both also supplying the three-wire system complete the power equipment of this plant.



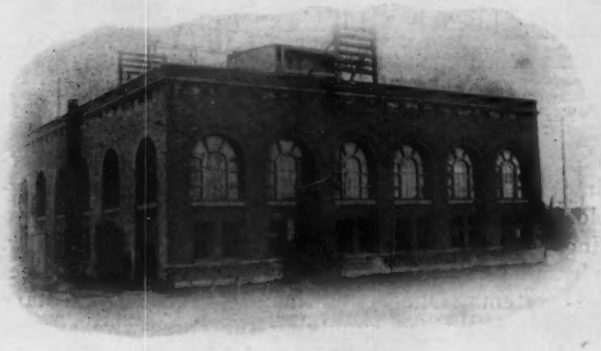
Georgetown Generating Plant.

Everett steam generating plant occupies a strategic position for fuel and power delivery, and when built represented a high class of steam plant design and finish. While it is held ready for operation at all times, it is used now only as a standby or emergency station. The plant is housed in a large square brick building of ornate design and is divided into two main sections, the one containing the boilers and accessories and the other the engines and electrical apparatus.

In the boiler room are two 450 h.p. and two 256 h.p. Babcock & Wilcox water tube boilers. Coal is delivered under the boilers by Greene automatic stokers which are driven by a small engine. There are two Worthington vacuum pumps and two feed pumps of the same make. On the wharf, a short distance from this station, is a three-cylinder, two-stage condenser pump, driven by a Westinghouse 25 h.p. type M., d.c. motor. In the boiler room is a New York blower for furnishing draft, driven by a Westinghouse 15 h.p. d.c. motor.

In the generating room there are two engine and one turbine steam generating units. The engines of the reciprocating units are similar, Allis-Chalmers, 750 h.p. Corliss type, one driving a 500 kw. Westinghouse

d.c. 600 volt railway generator, the other a Westinghouse 500 kw. 2200 volt, two-phase a.c. generator. The third unit is a Westinghouse-Parsons turbine of 750 kw. operating at 1800 r.p.m. and this delivers two-phase current at 2200 volts. A 25 kw. 55 volt d.c. exciter for the turbo-generator is direct connected to and driven by a two cylinder 8½ in. x 8 in. Westinghouse "Junior" engine.

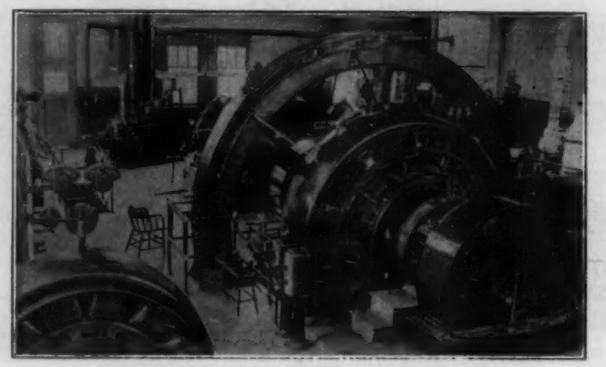


Everett Steam Plant.

The switchboard is of marble and has thirteen panels, these being divided as follows: three on generators, one on exciter, three on rotary-converter, two voltage regulators, two railway feeders and two on arc circuits.

One Westinghouse 250 kw. rotary-converter for railway service is in use here. There are finally two large Worthington steam pumps connected to the city water works system. One of these pumps placed on the engine room floor is double tandem compound and has a capacity of 3,000,000 gal.; the other is of the same type but one-half the capacity and is placed in the basement under the engine room.

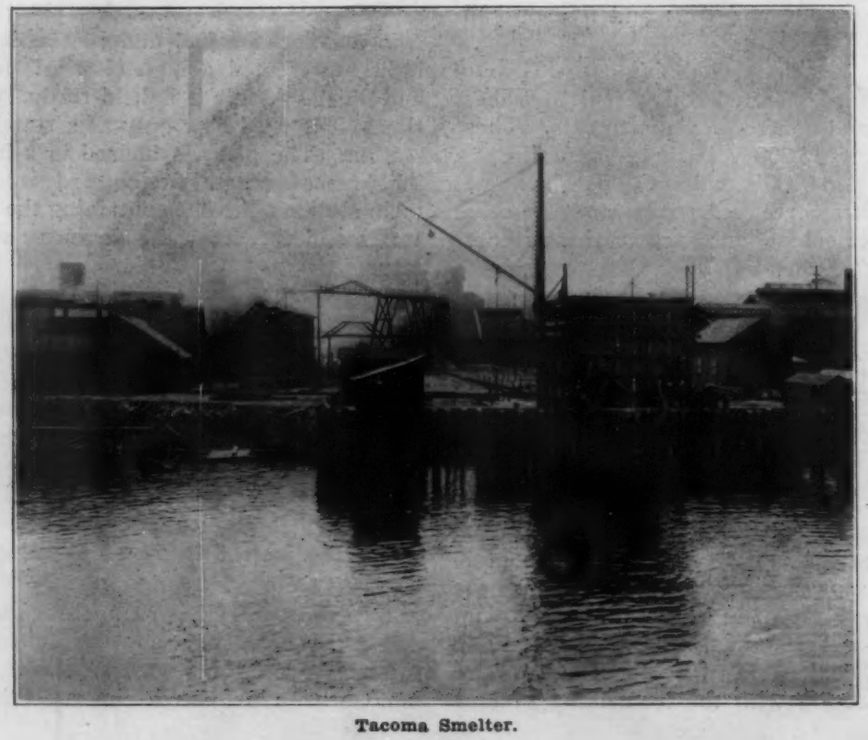
The Tacoma steam generating plant, station "A," is the principal steam plant of the city and is also a transformer substation. Like the others the steam plant is used only for emergency service, with the exception of the cable engine which is used in starting the cable which is driven by an induction motor. Even this service will be soon discontinued as it is proposed to install a motor of greater capacity capable of starting the cable.



Interior of Everett Steam Plant.

This station is situated at the commercial center of the city and adjacent to the Northern Pacific tracks and also the water front. It is a brick structure and adjoins the car houses and repair shops. At one end are the executive offices governing this division of the system.

Two transmission lines from the Electron and White River power houses enter this plant from the rear and, after passing through General Electric type H-3 motor operated oil circuit breakers, connect to a bus line. From this a circuit is carried through disconnectors and H-3 circuit breakers to one bank of two transformers. There is one spare transformer. These are General Electric, water cooled, 55,000 to 2300 volts and are T connected for two-phase second-



Tacoma Smelter.

ary. A 200 kw. General Electric transformer compensator is inserted in one phase to give a true two-phase circuit. There is also a 400 kw. non-automatic General Electric potential regulator on the 2300 volt feeders.

For the 13,800 volt supply to the Fern Hill steam plant, substation "B" and the Northern Pacific shops substation "C," there are four 500 kw. 2300 to 13,800

Station A at Tacoma.

volt raising transformers. There are two sets of H-3 motor operated circuit breakers, one on the raising transformers and the other for the main 2300 volt station circuit.

Carbon gap lightning arresters protect the incoming transmission lines.

The main engine space which occupies the space on the street side of the building is arranged with a jack shaft driven through two pulleys and rope drives from two Frick horizontal tandem compound engines of 750 h.p. each. The drives are of 2 in. continuous manila rope, each consisting of fifteen loops. At either end of the jack shaft is a clutch. Engaging the north end clutch and lined with the jack shaft are two 850 kw. General Electric synchronous motors, rigidly connected.. Similarly placed, but at the south end, are two 850 kw., d.c., 600 volt railway generators. Beyond these is a clutch which engages another driven pulley, which is driven by a Cooper 1000 h.p. horizontal cross compound engine.

Between the jack shaft and the front of the building, its shaft approximately in line with the shafts of the other engines, is a Pennsylvania horizontal Corliss engine direct connected to a Stanley, inductor type, 500 kw., two-phase a.c. generator.

The cable system is fitted with a 200 h.p. horizontal Corliss engine, but is regularly operated by a General Electric, variable speed, 100 h.p. induction motor .

The switchboards, in three sections, have two rows of panels facing each other and the third section at right angles in the rear of the switchboard space. There are altogether forty-five blue marble panels; five on commercial feeders and lighting; two on exciters; two on motor generator, a.c. and d.c.; three on synchronous motors; one on cable motor; seven on railway generators; five on oil switches; one booster; one totaling instruments; one bus multiple and seventeen railway feeders.

There is one four-bearing exciter set consisting of a 60 h.p., 2300 volt induction motor and a 125 v., 40 kw. d.c. generator, the speed of this unit being 605 r.p.m.

For railway service there are two 500 kw. motor generator sets. These operate at 400 r.p.m.; the motor is synchronous, 750 h.p. and operates at 2200 volts, two phase. The generator is an eight pole, 600 volt d.c., both being General Electric.

Fern Hill Substation and Steam Auxiliary, Station "B."

This plant is located several miles south of the center of the city but within the city limits, on the Spanaway railway line. It was built for railway service. The plant is housed in a one-story brick building, 80 ft. x 125 ft. In a recently constructed addition there are placed two General Electric 300 kw., 13,800 to 2300 volt, water cooled transformers for supplying two-phase current to one of the motor generator sets. Three sets of solenoid operated, General Electric type, K-12 oil circuit breakers mounted in cells are provided on the incoming 13,800 volt line, the other two operating on machine compensators. The circuits from the transformer house to the machines are carried under the floor in lead covered cables.

There are two motor generator sets, each having a capacity of 500 kw. One of these is a standard 514 r.p.m. set as used at other stations, and operating direct from the transmission line. The other is driven by a 700 h.p. synchronous, two-phase, 2300 volt motor at 400 r.p.m.

On the steam units there is one General Electric 200 kw., 550 volt, four pole, d.c. generator, belt driven by a Sioux City 350 h.p. Corliss engine and two old d.c. Edison bipolar, 500 volt generators of 100 kw. each, both belted to a 450 h.p. Stearns Corliss engine.

The boilers are ranged across the rear of the building, there being three 100 h.p. Phoenix 60x18, return tubular boilers and three 125 h.p. Stearns, 72x16, of similar type. This station receives its current supply over a single 13,800 volt circuit from Station "A."

Cornhill Station at Tacoma.

Bellingham York street station is a modern steam generating plant and contains also the step down transformers of the transmission line from Nooksack Falls.

The building is of brick with steel columns and steel and concrete floors. There are three Stirling water tube boilers of 505 h.p. each, fitted for burning oil, and two Warren 12x7x12 feed water pumps. There are two generating units, one being a Curtis 2000 kw. horizontal turbo-generator, operating at 1800 r.p.m. and delivering three-phase current at 2300 volts. The turbine exhausts into a Helander barometric condenser. A 35 kw. Curtis turbo-d.c. generator exciter is provided for this unit. The other unit is a 1000 h.p.

York Street Station at Bellingham.

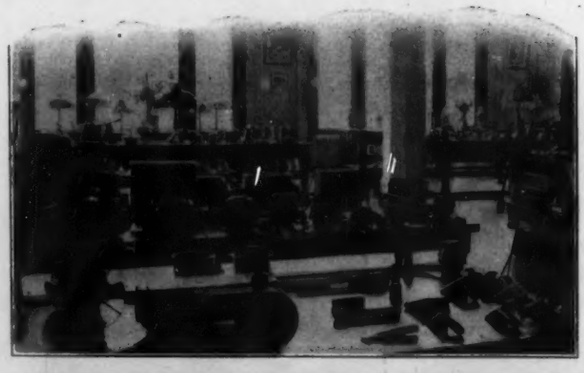
Interior of York Street Station at Bellingham.

Hamilton Corliss horizontal, cross compound, non-condensing engine, belted to a pulley which is connected through a clutch to a 500 kw., two-bearing, standard synchronous motor-generator set. This belt is three-ply and 72 in. wide and the driven pulley is 36 in. diameter. There is a second motor-generator set operating independently of the same size and specification. These supply current to the local railway system and the Bellingham end of the Skagit interurban line. The transformers are enclosed in an addition to the main building which also contains the Hamilton engine. The local distributing system is three phase for power and single phase for lighting.

The company also operates the gas works in Bellingham. Lowe crude oil and water gas apparatus is installed here. The annual output is about 40,000,000 cu ft. There are thirty-five miles of low pressure mains.

Show Rooms.

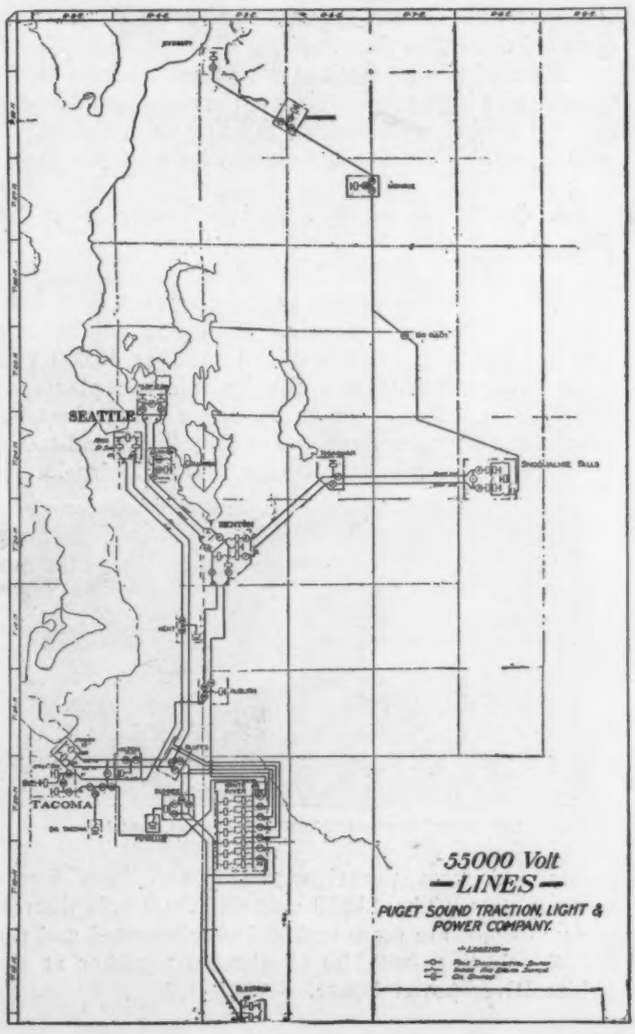
At all of the principal offices current consuming devices of every description are displayed for sale. The views below are of a very elaborate show room and an exquisitely furnished apartment, completely equipped in every one of its five rooms with electrical devices; all at the Seattle office.



TRANSMISSION LINES.

Typical Steel Tower Transmission Line Construction.

ORIGINALLY there were three distinct transmission line systems, two of which have now been brought to operate together. These are the system deriving power from Snoqualmie Falls and the one supplied from Electron and the Bellingham system from Nooksack Falls. The first two are now interconnected. There is no connection to the third. The two first named transmission systems are operated at a potential of 55,000 volts, delta connected at the transformers, are three-phase and 60 cycle. The Bellingham system, otherwise similar, operates at 38,000 volts. Throughout, native fir poles are used, spaced about 125 ft. apart, although in some cases, double this spacing has been recently made. A few miles of "A" frame steel towers have recently been installed on lines leading from the White River plant. All transmission lines carry a single circuit arranged in an equilateral triangle, one wire being mounted on a steel pin at the pole-top, the other two at the ends of a cross arm. Line construction is standard and telephone circuits are carried on an arm below the power wires. Steel pins and 4-part brown porcelain insulators are used. Secondary transmission lines operating at 13,800 volts are extensively used in Seattle and for supplying various outlying railway substations.



From Snoqualmie Falls are two parallel transmission lines, each carrying a single circuit of No. 0 aluminum strand to Renton switching station; from this point two parallel similar lines each No. 00 aluminum strand go to Tacoma and two to Seattle. In the former city the lines terminate at the main substation, one of them however having a loop into the White River power house. A third line of No. 4 copper is carried from Snoqualmie Falls to Everett, a distance of 40 miles being tapped into the substations at Monroe and Snohomish and terminating at the Everett substation.

From Electron are two transmission lines of No. 0000 copper quite similar to the preceding. These lines are carried to Puyallup, where they branch to two lines of No. 00 copper, going to Tacoma, and two lines of No. 0000 copper to Seattle. The former terminate at Station "A," the main steam generating plant. In Seattle, the lines terminate in the Massachusetts street substation. All other substations are supplied from the secondary 13,800 volt transmission lines.

A very complete telephone system is operated over the entire system. This is controlled from the central switchboard at Seattle, where the load despatcher has control of the operation of the entire system and is in telephonic communication with all points, in most cases over a number of different routes. There are three load despatchers, each having two shifts of four hours. At various points are secondary switchboards, where an operator has supervision of a local telephone system.

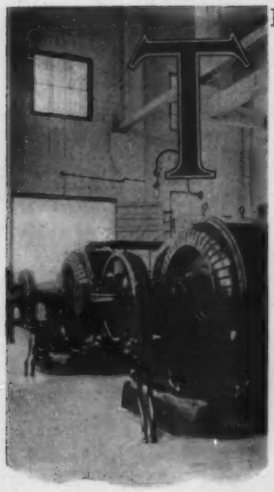
The transmission lines are protected at switching points by aluminum cell lightning arresters. There are also in use a number of carbon resistance type lightning arresters.

The rights of way for transmission lines in open country in some cases follow county roads, or the right of way of the interurban lines. Much of the line is, however, through the forest and here it is necessary not only to make an unusually wide clearing due to the great height of the native timber and the danger of its falling across a line, but it is also necessary to clear it every year from the rapidly growing brush growth, to prevent the spreading of forest fires which are a serious menace in this country.

Poletop disconnecting switches are installed wherever a connection is made to the transmission circuit.

The transmission line from Nooksack power house to Bellingham has a length of 40 miles. This line has a single circuit of aluminum strand equivalent to No. 2 copper. The insulators are standard 60,000 volt porcelain. The poles are native fir and are spaced 145 ft. apart and are 45 ft. long. This line follows a railroad or a county road for the greater part of the distance. At the present time it is being operated at 38,000 volts star connected at the transformers.

SUBSTATIONS.

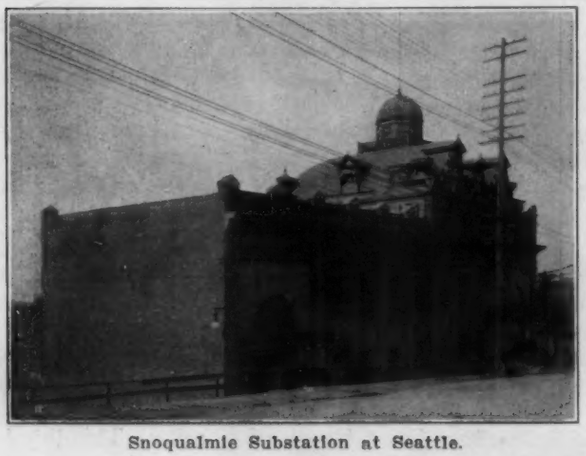


Interior of Union Street Substation

THE combined system includes 32 substations of which 13 are supplied directly from the 55,000 volt transmission lines, 9 from the high tension transmission of the Bellingham system and the remaining 10 are furnished with current from other substations at 13,800 volts and are therefore only used to supply a nearby local demand. In addition to these, two cable stations are substations only in the sense that they receive electric current to drive the cable motor.

In the type and design of substations there has heretofore been no one standard, but rather several types, as these stations have been constructed not only at different periods, some of them having been built in the early days of power transmission and therefore showing evidences of many changes, but also by the various companies which have now come under the general supervision of Stone & Webster. For this reason it will be impossible to describe any one substation as a type. On the contrary, much of the machinery with which the stations are equipped is similar and shows more or less standardization.

With the exception of six substations on the Snoqualmie system, they are equipped for railway operation and have one or more motor generators or rotary converters. There are in use a total of sixteen rotary converters, these being some of the earliest of the railway equipment, but it has not been the policy within recent years to use this type of rectifier. The motor-generators as now standardized are in two capacities, 1000 kw. and 500 kw. These sets have



Snoqualmie Substation at Seattle.

two bearings, operate at 514 r.p.m., the driving motor being of the synchronous type. The generator is eight-pole with interpoles for the larger size only, delivering full load current at 600 volts. The motor is equipped with a squirrel cage winding in the pole faces for starting and are supplied with three-phase current at 13,800 volts. The motors of the larger sets are rated at 1440 h.p., while the smaller sets are rated at 700 h.p. The make is General Electric.

As the distributing systems are all two-phase, two lowering transformers are used in every set, the Scott three-phase-two-phase connections being used. The transformers are of various types so that individual description will be necessary.

Switchboards are largely General Electric standard modern types, although there are a number of Westinghouse switchboards of modern type on the Snoqualmie system. Time limit relays are used on all incoming circuits.

Oil circuit breakers, whether they be for 2300 volts, 13,800 volts or for 55,000 volts are either motor or solenoid operated by remote control from the switchboards, lever connection control being occasionally used in the older stations. All oil circuit breakers are protected, if on 55,000 volt lines, by double break disconnecting pole top switches outside of the substations. In nearly all cases bar type disconnecting switches are also provided directly above the oil switch. The oil circuit breakers on the high voltage lines in the older equipments are General Electric type H-3 mounted in brick cells and motor operated, the leads being brought up through the floor from below; Pacific Electric 4-break automatic trip or hand operated breakers are also found. The newer installations are equipped with General Electric K-10 and K-15 solenoid operated circuit breakers.

Most of the substations are protected from lightning, if on a high tension circuit, the older installations being provided with carbon gap arresters, the newer with General Electric aluminum cell electrolytic lightning arresters.

A description of each station follows, grouping them in their localities:

Seattle Substations.

Seattle has two groups of stations, each with individual distribution networks. The Snoqualmie system has but one substation and receives 55,000 volt three-phase current from the hydrolectric plants of that system. The other group of six substations receive three-phase current either directly or indirectly from the Electron and White River hydroelectric

Interior of Snoqualmie Substation at Seattle.

plants and from the Georgetown and Post Street steam plants. The 13,800 volt and 2400 volt distributing systems are more or less interconnected and the 55,000 volt lines may be all thrown together at the White River power house.

The Seventh and Jefferson Street substation of the Snoqualmie system and the Massachusetts substation of the second group receive main line 55,000 volt current, the latter supplying 13,800 volt current to all of the other substations. Three of the recently constructed substations represent the most modern practice, Union Street, North Seattle and Ballard.

The Seventh and Jefferson Street substation is pretentious and was built during the early days of power transmission, being part of the system receiving power from Snoqualmie Falls. Until recently this substation has supplied a distributing system in competition with the other stations. Since its start in 1898 there have been a number of changes made and the capacity has been increased from time to time. The building commands a fine view over the commercial portion of the harbor and while on a side hill is in the very center of the city. It is of brick with considerable attempt at architectural adornment. The main floor is occupied by three rotary converters. These have a capacity of 500 kw. and deliver direct current at 550 volts. On a line down the center of the main floor is a Westinghouse switchboard of 25 panels. This switchboard is of white marble, on which are mounted round type instruments and Bristol recording instruments. Nine panels control 2200 volt, two-phase light and power circuits; one is for 13,800 volt, three-phase power; two are on transformer and bus multiple switches; one on the voltage regulator, three on the a.c. side of the rotary converters, three on the d.c. side of the rotaries, two are 600 volt d.c. railway panels, and two 500 volt d.c. commercial panels.

The two incoming transmission lines enter through porcelain tubes supported in glass panels and pass directly to Pacific Electric oil circuit breakers placed on the floor in the rear of the switchboard.

In the basement are placed the lowering transformers and potential regulators. The four 2500 k.v.a. Westinghouse water-cooled transformers are arranged in two banks, being Scott connected on the high tension side for 55,000 volts three-phase and on the low side for 2200 volts two-phase. There are also two 500 k.v.a. raising transformers of the same make which take current at 2200 volts and deliver 13,800 volts, two-phase, as well as two Westinghouse water cooled 500 k.v.a. transformers taking current at 2200 volts and delivering 370 volts to operate the rotary converters. In addition there are four oil immersed, air cooled transformers of the same make, size and specifications. The oil circuit breakers operated from the switchboard are mounted from the ceiling of the basement directly under the switchboard. On the transformers are two Westinghouse and one General Electric voltage regulators, the latter being motor operated and having a capacity of 500 kw. On the lighting feeders are four Westinghouse and two General Electric 40 kw. motor operated voltage regulators.

The Masachusetts Street transformer substation on the water front on the southern edge of the business section of the city receives the two 55,000 volt circuits from the White River and Electron power plants. When built in 1902 this substation was intended only as a feeder for the Seattle and Tacoma interurban railway, but it was remodelled in 1904 to receive current from the newly-completed Electron plant. Later, in 1911, when the White River plant was built, it was again remodeled to accommodate the greater capacity. The substation is of brick with a wooden roof, covering a ground space of 50 ft. wide by 80 ft. long. It is divided into two sections, one containing the transformers at the ground level and over these is a room in which are placed the aluminum cell lightning arresters. The transmission lines are brought through roof insulators over the lightning arresters and are led to disconnecting switches, thence into General Electric H-3 oil circuit breakers, then through another set of disconnectors, each line to one of two busses. From each bus is a circuit passing through disconnecting switches only, to a bank of transformers. There is a third bank of transformers protected by an oil circuit breaker and two sets of disconnectors from which are lines to each bus. The bus lines are connected through an oil circuit breaker and two sets of disconnectors.

All of the high tension wiring is insulated, i.e. it is covered with 18/32 in. varnished cambric and then two layers of asbestos flame proof fabric, to prevent as far as possible the danger of fire from short circuits.

Two 10,000 k.v.a. three-phase General Electric water cooled, transformers, lower from 55,000 to 13,800 volts. In addition three 2000 k.v.a. (one being a spare) transformers are Scott connected and deliver two-phase current at 2300 volts.

The five outgoing 13,800 volt circuits, each one feeding a substation which does not receive 55,000 volt current, are 4-0 cambric insulated and pass through bar disconnecting switches, each lead also being provided with a grounding switch.

On the main floor are the 13,800 volt and also the 2300 volt oil circuit breakers. These are General Electric, motor operated, mounted in concrete cells, and are equipped with selector disconnecting switches for two bus lines.

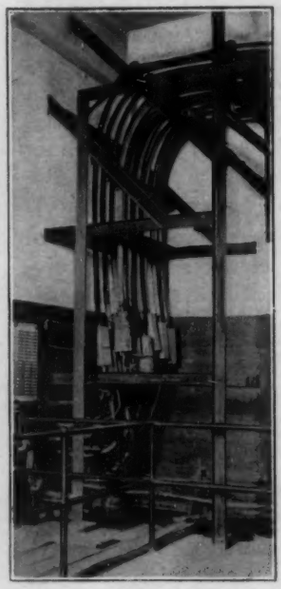
In one phase of the 2300 volt circuits is a 240 kw. compensator transformer as well as a pair of 340 kw. induction regulators.

The two-phase 2300 volt circuit supplies light and power in the immediate neighborhood to mills and factories and is also connected with the Post Street steam plant.

An ingenious arrangement for the supply of cooling water is used because of the local supply conditions. The warm return flow from the transformers passes through a set of 1 in. brass tubes into a wood tank. These tubes are immersed in a larger wood tank through which salt water from the Sound is circulated. The fresh water tank is maintained at a predetermined level, any leakage or evaporation being automatically supplied from the city mains. A 10 h.p. induction motor driven centrifugal pump forces the fresh water from the tank through the transformer coils. The salt cooling water is circulated by two 10 h.p. induction motor-driven centrifugal pumps, one being placed close to the intake at the Sound, the other within the substation.

Of the two switchboards the main one is a modern General Electric standard equipment of thirteen blue marble panels. Of these, two control the incoming transmission lines; three the low tension side of the transformer banks; two the 2300 volt tie line feeders;

Union Street Substation at Seattle.



Cable Entrance at Union Street Substation.

Switchboard of Union Street Substation.

one is for graphic recording instruments and five on outgoing 13,800 volt feeders. The second switchboard has three panels, two of which are for local 2300 volt power circuits, while the third is for local lighting.

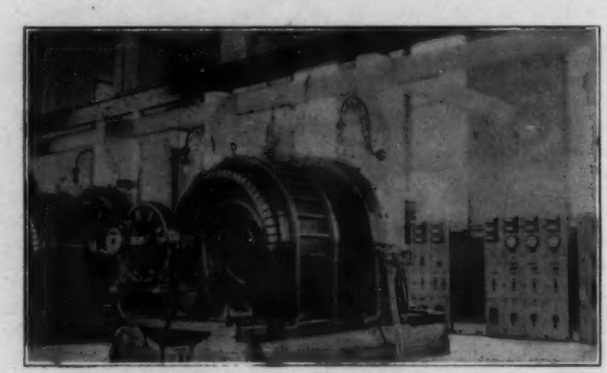
Union Street is of a late type and modern design. It is of reinforced concrete and was designed to be extended when the service requirement should make this necessary; this extension is now under construction. The finished structure will be 45 ft. wide and 100 ft. long. The structure is heavy, the center columns being designed to carry a load of 740,000 lb. The situation of the building, while practically on the water front at the very center of the city, is on a steep side hill and makes possible, besides the main floor, a basement and a sub-basement. In the sub-basement and in one-half of the basement is to be installed a storage battery of 77 cells similar to the one in operation in the Post Street plant, capable of supplying 2600 kw. for one hour. In the present basement are the oil circuit breakers and their disconnecting switches. These are General Electric, style K-4 on the 2300 volt circuits and K-12 on the 13,800 volt three-phase circuits. The wiring and disconnectors are mounted on iron pipe framing. There are eleven oil circuit-breaker sets mounted in concrete cells. One 340 kw. two-phase General Electric induction regulator is also connected to a 500,000 c.m. 2300 volt circuit coming from the Post Street station.

On the main floor are three motor-generator sets; two of these are of 500 kw. capacity, of the standard type and used by the company. The motor is synchronous, of 710 h.p. The generator delivers direct current at 275 volts into the Edison three-wire system. A 10 kw. 125 volt exciter is mounted on the end of the shaft. The speed of these sets is 720 r.p.m. Two-phase current at 2300 volts potential is supplied by two Scott connected, 1000 kw. vertical type, air blast General Electric transformers. The remaining two-bearing motor-generator is of 1000 kw. capacity; the synchronous motor being rated at 1440 h.p. The generator delivers direct current for the Edison three-wire system at 275 volts and is operated at 514 r.p.m. The supply current comes directly from the Massachusetts Street substation at 13,800 volts, three-phase. In the addition, nearing completion, will be placed two 1500 kw. motor-generator sets.

The switchboard is of blue marble in nineteen panels from the General Electric Company. There are six motor-generator control panels, one graphic recording instrument panel, one controlling the 13,800 volt feeder to the 1440 h.p. synchronous motor and one for the transformers; two on feeders to Seventh and Jefferson Street substation and the Massachusetts Street substation respectively, and eight panels feeding Edison three-wire circuits.

North Seattle substation, situated at the northern part of the main commercial section of the city and adjoining one of the car houses, has been recently constructed and is quite similar to the one just described. This building is reinforced concrete, having a main floor and basement. The basement is taken up by the

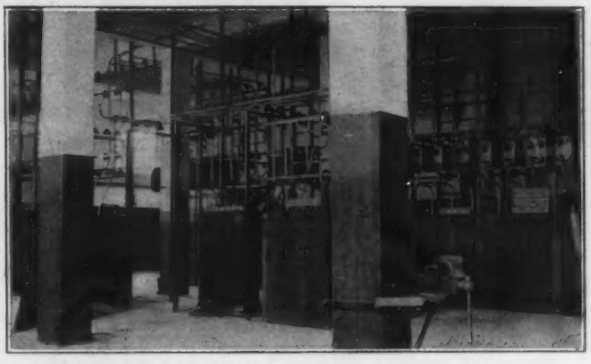
North Seattle Substation.



Interior of North Seattle Substation.

oil switches and disconnectors, the method of mounting and type of apparatus being the same as at Union Street. There is a wire tower at one corner of this building, the incoming circuits being brought down the tower into the basemment. There are two incoming 13,800 volt three-phase circuits, two outgoing 2300 volt two-phase power circuits, three single-phase lighting circuits, two of them being equipped with induction regulators and 8 railway feeders which pass into underground ducts. Of the oil circuit-breakers, there are two on transformer sets, four on both sides of two compensators, one on high voltage motor and four on single-phase circuits. These are operated from an Electric Storage Battery Company's type 7-E storage battery.

On the main floor are one pair of 1000 kw. air blast transformers, which supply the single-phase currents for lighting. There are two motor generator sets of the standard type, the motors being wound for 13,800 volts three-phase.



Basement Switchroom in North Seattle Substation.

The switchboard is of 21 panels of which four control the a.c. and d.c. sides of the motor-generators; one is on the exciters; three on 13,800 volt feeders; four on commercial light and power and eight on railway feeders.

An electrically operated, 20-ton travelling crane completes the equipment of this station.

Ballard substation in the suburb of this name at the northern extremity of Seattle, is comparatively recent but of quite a different arrangement from those just described. The building is of pressed brick. The switch gallery is of reinforced concrete and is supported on one side by the building walls and on the other by three columns of the same material. This leaves one-half of the building an open bay.

On the main floor of this substation are two motor-generator sets, of the adopted standard type, one set of 500 k.w. and the other of 1000 kw. capacity. Space is available for a third set to be installed at some future date. The motors receive three-phase current at 13,800 volts. A pair of General Electric, 1000 kw. air blast transformers, Scott connected, supply a local 2300 volt light and power service. Air for cooling is supplied by a Buffalo Forge Company's blower driven by a 5 h.p. induction motor.

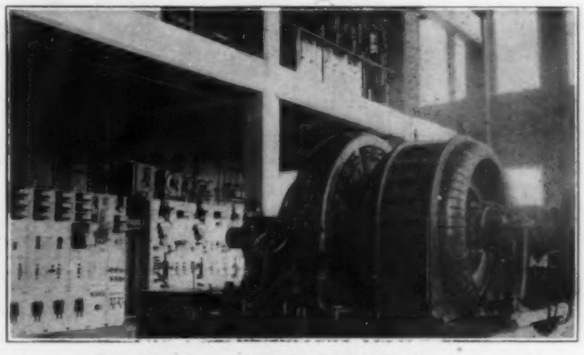
There are three 13,800 volt three-phase lines, one direct from Massachusetts Street substation, one from Fremont substation and one feeding a line to Everett.

The switchboard is of blue marble and has 18 panels. These are similar in plan to those described, there being five panels on the motor generators, one for a General Electric T. A. regulator, four on 13,800 volt circuits, four on 2300 volt light and power circuits

Ballard Substation.

and five on railway feeders, one of these feeding the Everett interurban railway. The 13,800 incoming circuits as well as those to the a.c. side of the motor-generators are carried in lead covered cable. One type 7-E Chloride storage battery operates the oil circuit breakers. These are General Electric K-4 switches mounted in brick cells, there being seven three-phase sets, one two-phase, 2300 volt and three single-phase, 2300 volt sets. There are two 46 kw. potential regulators on the lighting circuits and a single equipment of General Electric aluminum cell lightning arresters.

Fremont substation, situated in the Fremont addition, just north of Lake Union, is one of the earlier substation and is used for railway supply only. The building is of brick, one-story in height. Originally part of the space was occupied by a storage battery, which has been abandoned. The main part of the station is occupied by two 1000 kw. motor-generator sets of the standard established type, the motors being wound for three-phase current at 13,800 volts. The switchboard is in 17 panels and is similar to the preceding ones with the exception that there are no 2300 volt lighting or power circuits. Three 13,800 volt three-phase lines are brought from the pole, through



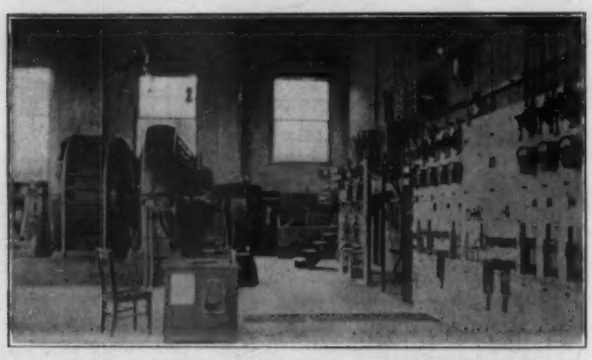
Interior of Ballard Substation.

lead-covered cable into the station. Two of these circuits come from the James Street substation and lead into one oil switch through selector switches, the third comes from the Massachusetts substation, via the James Street substation and has its own oil switch. There are therefore two sets of General Elec-

tric K-4 oil circuit-breakers. On the motor-generators and compensators are five sets of K-12 oil circuit breakers. The switches and disconnectors are in a room adjoining the main machine room. This station is also equipped with a type 7-E control storage battery for operating the oil switches and supplying emergency lights.

Fremont Substation.

James Street substation also includes a cable driving plant, operated both by steam engine and motor drive, and a car house. These features will be described under the headings of "Cable stations" and "Car houses."



Interior of Fremont Substation at Seattle.

This is one of the older stations, an inheritance from one of the numerous companies, now part of the system. It is situated in the geographical center of the city a few blocks to the east of the commercial district and on the top of the hill or ridge which divides the water front from Lake Washington. Being on a side hill, the brick building is but one-story in height, but the main operating floor occupies a large basement.

On the main floor is the storage house for cable cars, while adjoining this and on the street level are the switch compartments. The incoming feeder circuits to this substation are all 13,800 volts three-phase. Two of these circuits are brought directly from the Massachusetts Street substation and one circuit from the Georgetown steam generating plant. These circuits are led into the building through three-conductor lead-covered cables. Two outgoing 13,800 volt circuits furnish current to the Fremont substation. The oil circuit breakers, which are General Electric K-12 switches, are mounted in concrete cells in two general rows, in the same manner as described for other substations. On one side are two sets of circuit breakers on transformers, a set on each of the incoming and outgoing lines, and two sets on compensators for starting the a.c. machines. In the other row are the oil circuit breakers for the two-phase 2300 volt outgoing circuits for power and lighting. There are also 13,800 volt, H-3 type circuit breakers as follows: one on the line supplying the Yesler Way cable station motor, one for coupling the bus, and four controlling the circuits to the motor-generators. On this floor are two sets of General Electric aluminum cell lightning arresters, one to each 13,800 volt bus. Finally there are two blowers, which supply cooling air to the transformers, each driven by a 5 h.p. General Electric induction motor.

On the lower floor are the transformers, motor-generators and switchboard in three sections.

The four transformers are 1000 kw. General Electric air blast type and are Scott connected for 13,800 volts, three-phase, on the primary to 2300 volts, two-phase on the secondary side. There are four motor generator sets, all of them being of the standard type previously described, two of them of 500 kw. and two of 1000 kw. capacity.

A railway car air compressor driven by a 5 h.p. direct current motor is used for cleaning purposes.

The switchboard is set in two lines with a section at the end of the room. There are 41 panels and control circuits as follows: two transformer circuits, five 13,800 volt transmission circuits, four 13,800 volt a.c. motors, four on the d.c. side of motor-generators, three on cable motors in three-cable stations, 2300 volts; thirteen 2300 volt feeders and tie lines to Post Street station, eleven d. c. railway feeders, and one railway total panel. These panels are General Electric blue marble on which are mounted a modern equipment of General Electric indicating and Bristol recording instruments.

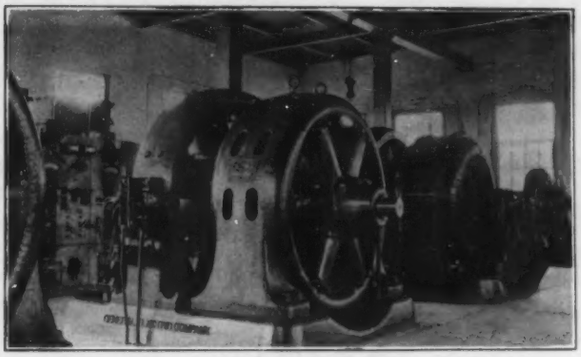
A General Electric potential regulator on a 2300 volt tie line connects with both the Post Street and the Seventh and Jefferson Street stations. This regulator is arranged with disconnecting switches on both sides; behind each disconnector is a tap, the lines from these taps joining through an oil circuit breaker. By this means the circuit may be cut around the regulator, and the latter may be taken out of the circuit. All of the oil circuit breakers are solenoid operated.

West Seattle substation is situated south and west of the main city in the suburb of that name. It is an attractive one-story brick building with one large operating room and wire tower at one corner. Three motor-generator sets are installed with a space for a fourth. The first of these has a capacity of 500 kw. driven by a 700 h.p. 514 r.p.m. 13,800 volt three-phase synchronous motor of the company's standard type The remaining two sets are of 300 kw. each, the motor being induction type, 450 h.p., 2300 volts, two-phase, the generator, 600 volts, 8 pole. These sets are two bearing and operate at 450 r.p. m.

There are two 500 kw. General Electric air blast transformers, Scott connected, 13,800 volts, three-phase to 2300 volts, two-phase. Cooling air is supplied by two Buffalo blowers, each driven by a 2 h.p. induction motor. Three sets of General Electric K-12 solenoid operated oil circuit breakers are mounted in

concrete cells and provided with disconnecting switches mounted on pipe frames.

In one corner, adjoining the wire tower, is a set of General Electric aluminum cell, electrolytic lightning arresters.

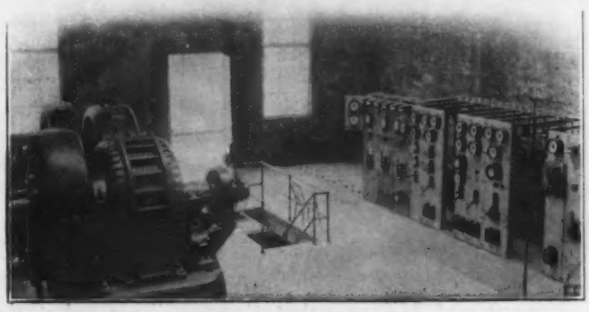


Motor Generators at West Seattle Substation.

The switchboard, consisting of 10 panels, is of the modern General Electric type, similar to those in other substations. There are 6 panels controlling the a.c. and d.c. sides of the motor-generators and four railway feeder panels.

Everett substations. There are two substations in Everett, which until recently have supplied competitive systems. The older substation is part of the Snoqualmie system while the other is comparatively new. They are within a short distance of each other.

The older station is of brick, 20x30 ft., with a corrugated iron addition 20x20 ft. Installed in the main part are three 1000 kw. Westinghouse transformers, one of them being a spare, Scott connected on the primary side for 55,000 volts and on the low tension side 2300 volts two-phase. Above the transformers on a steel frame are three single pole, Pacific Electric Mfg. Co., oil circuit breakers. There are four Westinghouse booster transformers on the outgoing 2300 volt lines. In the addition are five General Electric, 6.6 amperes, 30 kw. arc tubs. These supply the city arc lighting system of 231 lamps. There is a three-panel switchboard in which the first panel controls the transmission line



Interior of Broadway Substation at Everett.

switches, instruments, etc., the second the booster voltage and the a.c. switches for the railway machines in the other substation and the third, the light and power circuits. Poletop disconnecting switches are provided outside of the building.

Broadway substation is a substantial one-story reinforced concrete building 60x60 ft., with an addition of greater height, giving a total length of 120 ft. to the building. This addition was built to provide for transformers and high tension switching apparatus,

West Seattle Substation.

but due to a change in plans this has not been installed.

On the main floor of the building are installed two motor-generator sets; one of these has a capacity of 500 kw. and is of the standard type of General Electric apparatus used by the company. The other set has a capacity of 400 kw. driven by a synchronous motor of 450 h.p. at 450 r.p.m. The d.c. exciter is mounted at the end of the shaft in the conventional manner.

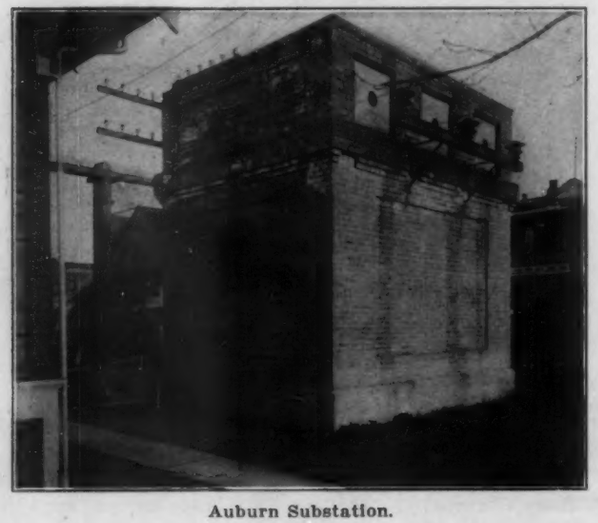
The switchboard consists of twenty panels. There are five 2300 volt two-phase circuits, including a tie line between the stations; one totaling d.c. railway panel; one Tirrill regulator panel, four controlling the a.c. and d.c. sides of the motor-generators; one each for d.c. and a.c. motors; one a.c. compensator; one d.c. power; one on railway feeders; two controlling arc circuits and water works pump motors.

Switches and Transformers at West Seattle Substation.

In the basement are the pumps for the city water works system. There are two Worthington pumps of 3,000,000 and 2,000,000 gal. capacity respectively. The first is a two-stage pump delivering water at a pressure of 90 lb. to the square in. and driven by a 250 h.p. 2300

volt, variable speed General Electric induction motor. The other pump is driven by a 150 h.p. motor of similar type and specification.

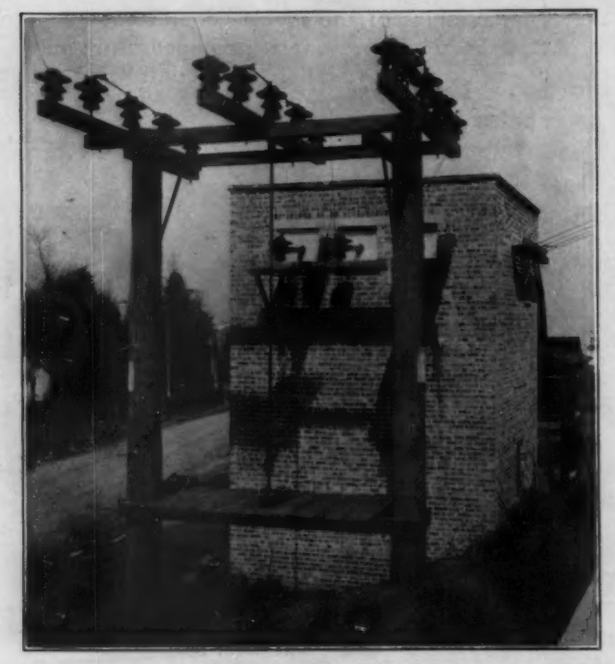
The pumps deliver water either directly into the city mains or into two cement reservoirs, the older



Auburn Substation.

having a capacity of 3,000,000 gal., while the latter which has been recently completed at a cost of $100,000, has a capacity of 10,000,000 gal.

Ordinarily the total supply of power for the city and the railway system is supplied from these substations, they are however tied in with the steam generating plant which is held as a standby. This plant is described under "Steam generating plants."

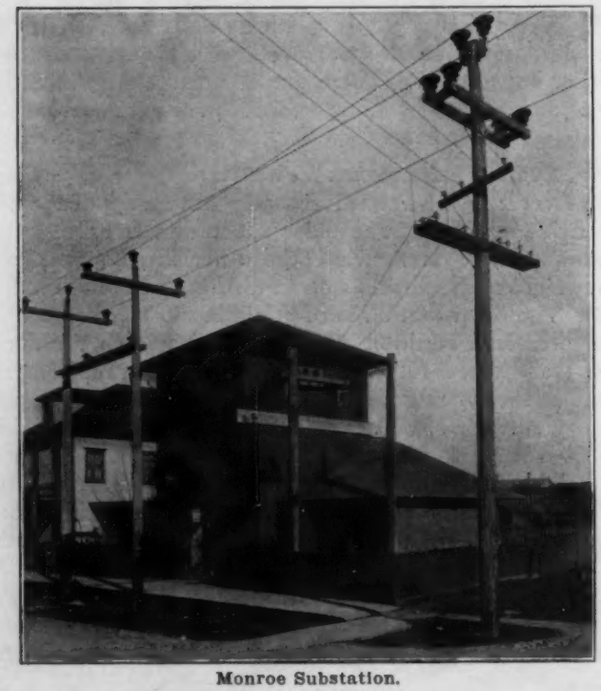


Issaquah Substation.

Bellingham substation. The main substation is integral with the auxiliary steam plant which is described under the head of "Steam generating plants." The three 500 kw. lowering transformers in this station are connected to the transmission line from the Nooksack Falls power plant and are similar to the raising transformers. They will be changed during the coming summer when the transmission is changed for 55,000 volt operation. A second substation at South Bellingham is at the gas works. This substation contains three 100 kw. Stanley oil immersed, air cooled transformers, delta connected for 38,000 volts primary and 2300 volts secondary, the distribution being single-phase for lighting and three-phase for power.

Snohomish substation. This substation receives current at 55,000 volts from the Snoqualmie-Everett transmission line. The building is of brick, the transformers are owned by the local gas company, the building and switches, by the power company.

Issaquah, Auburn and Monroe substations. These substations are on the Snoqualmie-Renton, Snaqualmie-Tacoma and Snoqualmie-Everett lines, respectively. They are of brick 20 ft. x 15 ft., with concrete roof, the former and latter contain one and the Auburn



Monroe Substation.

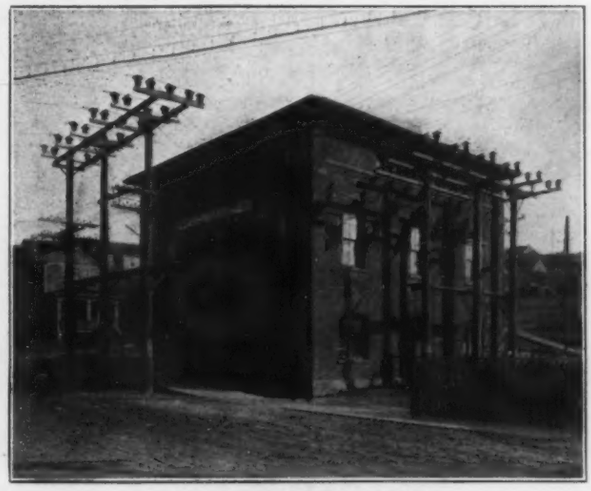
two, Westinghouse oil immersed, air cooled 100 kw. transformers, 55,000 to 2300 volts, in the latter case Scott connected for two-phase distribution. The circuit from one transmission line, which is sectionalized at these points with pole-top disconnecting switches, is brought into the buildings through tube insulators inserted in glass windows to Pacific Electric oil circuit breakers. These switches are mounted above the transformers on "I" beams.

The switchboards are a single panel of Westinghouse instruments mounted on white marble.

Kent and Milton substations. These substations were designed primarily to supply power to the interurban railway between Seattle and Tacoma, but each now supplies also a local light and power service. They are similar in design and arrangement and vary only slightly in equipment. The buildings are of brick. equal to two stories in height, with a one-story addition in the rear containing the storage battery. These

substations receive 55,000 volt three-phase current from what is known as the "Electron line," which is built along the railway right of way, but in each case a circuit from but one transmission circuit is brought into the building. In the case of the Kent substation, the main line is sectionalized with two sets of pole-top disconnecting switches and two leads are taken off, each from the same line outside of the disconnectors. These circuits are brought into the building through 24 in. tiles fitted with glass panes. One of these, after passing through a disconnector, taps into the bus line, while the other passes through a General Electric H-3 oil switch mounted in brick cells, and which is protected by two sets of disconnectors. From the bus a circuit is carried, through an oil switch and two multiple sets of disconnecting switches to two sets of transformers. The storage battery consists of 288 "Chloride" cells, being the same in both stations.

At Kent are two pairs of transformers for power and a fifth for local lighting. These are General Electric oil immersed and air cooled, 200 kw. 55,000/2300



Renton Switching Station.

volts and are Scott connected for two-phase secondaries. At Milton there is at present but one pair of similar transformers, although they are water-cooled. In both station there are two 300 kw. motor-generator sets. These sets are two bearing with a 450 h.p. two-phase induction motor and 600 volt 8-pole d.c. generator and operate at 450 r.p.m.

Each station also contains a booster set for charging the battery. This consists of a 53 h.p., 4-pole, d.c. motor with a voltage variation of 600-700 volts and speed from 600-660 r.p.m., driving a 6-pole generator, designed to deliver from 60-120 volts.

The switchboard has 9 panels (at Kent there is an additional railway feeder panel) as follows: 2 for induction motors; 3 d.c. generator panels; 1 d.c. total panel; 2 railway feeders; 1 local lighting.

General electric carbon resistance lightning arresters complete the equipment of each building.

Renton substation. This is one of the most important of the substations as it is a sectionalizing point of the two main branches from Snoqualmie Falls. The building is of brick, two stories in height, a new and larger building is soon to replace the present one and will contain an operating room and a standard motor-generator set. On the second floor are the oil switches, while on the first floor is a set of transformers supplying local power to a nearby col-

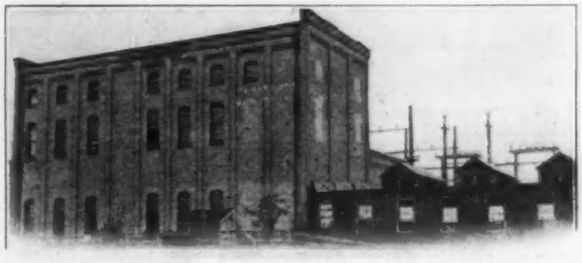
Milton Substation.

liery and a switchboard for local service. The transformers are three 500 kw. Westinghouse air cooled, oil immersed, in corrugated sheet iron cases. They are delta connected 55,000 to 2300 volts. A series arc service on two lines, 6.6 amperes, is operated from this point.

Two main 55,000 volt circuits enter the station from Snoqualime Falls, while four circuits leave the station, two for Seattle and two for Tacoma. Of the latter, one is looped into the new White River generating station. All lines are equipped outside of the building with poletop disconnecting switches. Entrance is made through 42 in. x 3 in. porcelain tubes, mounted in marble slabs which are in turn inserted in window openings. All oil circuit breakers are protected with disconnectors manufactured by the company.

There are two sets of General Electric K-10 circuit breakers on the Snoqualmie lines; 1 set for connecting bus lines; 1 set Pacific Electric Mfg. Co. on the local transformer circuit; and 1 set General Electric K-15 circuit breakers on both Tacoma lines.

Puyallup substation. This substation is supplied from the "Electron" transmission at 55,000 volts. It is a brick building and contains two 100 kw. General



Kent Substation.

Electric transformers, Scott connected to deliver 2300 volts, two-phase. Besides supplying the town, a service is extended to the town of Sumner.

Tacoma.

In this city are four substations. One connected with the Snoqualmie system is purely a substation without a steam auxiliary. Station "A," the main steam power plant and now used as an auxiliary, con-

tains the remainder of the high tension substation apparatus. Station "B," at Fern Hill, a suburb, is a railway substation and steam auxiliary. Station "C" is a transformer station for the Northern Pacific Railway shops at South Tacoma.

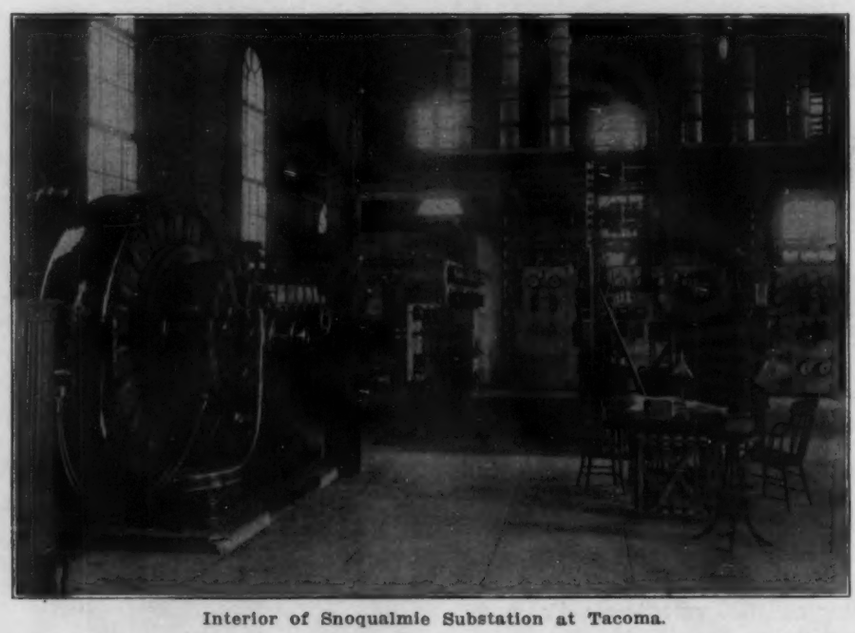
Snoqualmie Substation at Tacoma.

Snoqualmie substation. This, like the substation in Seattle, is a large brick building with a considerable attempt at architectural adornment. Since its erection it has gone through most of the changes incident to the various epochs in the development of long distance transmission. Upon the main floor are the switchboards, part of the transformers, a rotary converter and offices. On the basement floor are transformers, regulators and storage rooms. Upon a gallery are the high tension circuit breakers and lightning arresters. Two transmission circuits from Snoqualmie Falls, after passing through poletop disconnectors, enter through porcelain tubes. There are three sets of Pacific Electric oil circuit breakers, hand-operated from the switchboard and one set of General Electric K-15 circuit breakers operated in a similar manner. These switches are on both the incoming lines and transformer sets. Four 2500 k.v.a. water cooled, Scott connected, Westinghouse transformers, 55,000 to 2300 volts are placed under the switch gallery, but in the basement. Three 1000 k.v.a. 55,000 to 27,600 volt, Westinghouse oil immersed air cooled transformers, delta connected on both sides, supply current to the copper smelter at old Tacoma. There is one 500 kw. Westinghouse potential regulator for the city distribution lines. The remainder of the apparatus in the basement consisting of eleven boosting series transformers and 18 a.c. arc light tubs, are part of the municipal system of the city which receives its current supply from this substation.

On the main floor a 500 kw. Westinghouse rotary converter receives its a.c. current from two 300 kw. Westinghouse air cooled and oil immersed transformers, having a primary winding for 2300 and secondary for 390 volts.

A 10 ton, triplex block, hand operated travelling crane, having a span of 15 ft., runs the length of the building, being supported by the wall on one side and a rail placed on columns on the other. Westinghouse aluminum cell lightning arresters placed in the gallery for the incoming lines completes the equipment of this station.

The three remaining substations in Tacoma will be described under the heading of "Steam generating plants."

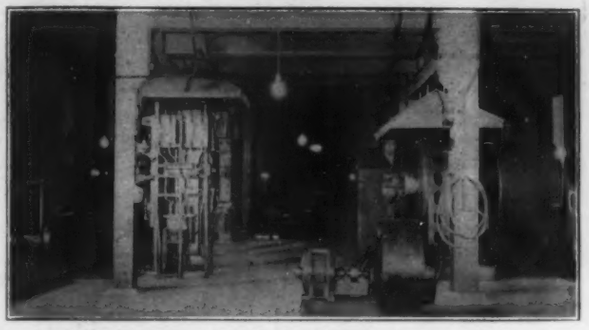


Interior of Snoqualmie Substation at Tacoma.

Bellingham-Skagit Railway Substations. The two substations for this railway system when it is completed in the summer of the present year, will be situated at Clayton Bay and at Burlington. These substations will be concrete structures and each will be equipped with one 500 kw. standard motor-generator set operating at 514 r.p.m. and will be supplied with suitable transformers wound for 55,000 to 2300 volts. A transmission line feeding these stations will be of aluminum equivalent to No. 1 copper. Three-phase distribution systems at Burlington and Sedro-Wooley for lighting and power will get current from this circuit.

Cable Driving Plants. Of the four cable driving plants included in this system three are in Seattle and the fourth in Tacoma. The machinery for these plants is conventional and quite similar. Until re-

cently they have, with one exception, been driven by steam engines and these remain in service, to be used in the event of failure of the driving motors. All of the driving motors are General Electric 2300 volt, two-phase, variable speed rheostat control, induction type, of 300 h.p. capacity with the exception of the Tacoma installation. This last named is to be eventually replaced with a motor of 200 h.p.



Madison Street Cable Driving Plant at Seattle.

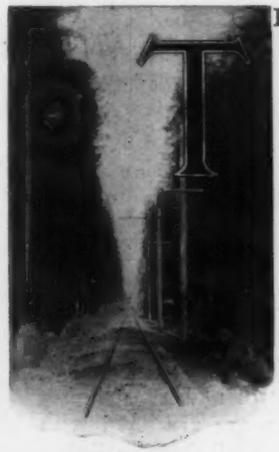
In Seattle, the cable lines are approximately parallel and operate from the main business sections in an easterly direction over the hill between the water front and Lake Washington. The James Street line is operated from the plant in the James Street substation, the Madison Street line from a driving plant located in the basement of the Madison Street car house. The Yesler Way line terminates on the shore of Lake Washington at the steam driving plant and car house originally built for this line. In this plant are three return tubular boilers and two Corliss engines of 250 h.p. and 200 h.p. respectively. The steam plant in this station will be eventually dismantled.

In Tacoma the cable system is quite similarly situated to that of Seattle. It is now driven by a 100 h.p., 600 r.p.m., 2300 volt, two-phase General Electric induction motor. There is also a 200 h.p. Corliss engine which is used in starting the cable.

Minneapolis Type Type Car at Tacoma.

The towns of Maple Falls and Glacier are lighted, a single 50 kw. transformer being connected to one wire of the transmission, the other side being led to ground. A branch line 5 miles long supplies power to a mill. At this point is a substation containing three 100 kw. transformers. Westinghouse low equivalent lightning arresters are installed at either end of the transmissoin.

Railway Systems.



On the Seattle-Everett Interurban.

THIS company operates seven railway systems, now more or less interconnected. These comprise the Seattle city lines, the Tacoma city lines, the interurban between Seattle and Tacoma, the interurban between Seattle and Everett and the Everett city system, and the Bellingham and Skagit interurban system, and the Bellingham city system.

Car Equipment.

The car equipment of the first two systems is quite similar, the so-called "Minneapolis" type city car being much favored. This car is single ended. About two thirds of the car from the front is closed, the remainder open, with blinds for inclement weather. The rear platform is large and is open. All cars are "Pay on entering," and the conductor is invariably stationed on the rear platform within a pipe frame enclosure. All cash fares are paid into a coin box. In both cities a number of single truck cars are still in use, these being provided with gates and the P. O. E. feature. In both cities a number of double end cars are in use. These are entirely closed. Entrance is at the rear but exit is both front and rear. The gates in both this and the single truck type are operated by a lever movement from the motorman. In the "Minneapolis" type cars both exit and entrance gates, each consisting of two steel wicket gates opening outward, are operated by the conductor. A new type of double truck, double end steel car has been adopted for use in Seattle.

As before stated there are three cable lines in Seattle and one in Tacoma. These lines are 3 ft. 6 in., narrow gauge. The cars are double truck and will seat about 32 people. A flat jaw grip is used operated by a lever. Both wheel and track brakes are used, the

New Type Steel P. O. E. Car.

former operated by a lever and the latter by a foot lever.

The standard color adopted for all cars is a dark olive green. This is a recent change from orange which has been heretofore used and all cars will be eventually painted the new color.

The cars in use on the Seattle-Tacoma interurban are of two general types, differing in the details of the

car body only. On local trains, two cars are generally used, the forward car having a baggage compartment, the rest of the car being a smoker. The other car is a standard passenger coach. On the expresses, but one car is ordinarily used; this is divided into three sections, a smoker, coach and parlor car. The seats in the coaches and smokers are transverse with cane backs and bottoms, in the parlor car section are cane chairs with velvet cushions. The car equipments are four motor, General Electric multiple unit control.

On the Seattle-Everett system six single cars are operated. These were furnished by the Niles Car Company and are 52 ft. long, have a seating capacity of 56 and weigh 40 tons. The equipment is four 75 h.p. No. 73 General Electric motors (without interpoles), General Electric multiple unit control and Westinghouse air brakes. The arc headlights are arranged with a three-point switch which gives full light, dim light for use in the city streets, and off. The cars have two compartments and are handsomely finished in mahogany.

On the Everett city system there are 17 cars, six of which are single truck.

Cars for the Bellingham-Skagit line will have Westinghouse four motor equipments with multiple-unit pneumatic control.

Both interurban and city lines do freight business. On the former regular trains are run at night; on the latter building and other materials are distributed about the city.

Where there are sections of single track which diverge into double track and vice versa, a suspended signal switch is used. This switch, which is built by the company, hangs directly over the track and from it are dropped two ropes to a height such that the motorman in his car may reach up, grasping a rope, thereby throwing the switch. In series with the switch is a group of five lamps placed at the other end of the single track section. Upon coming on to the single track the switch is thrown to light the lamps at the other end, thus warning a car from the opposite direction from going on to the single track. Upon reaching the double track again the switch at the other end turns the lights off and thus the track is cleared.

Interurban Depot and Cars at Everett.

Tacoma City Lines.

In Tacoma the city lines are quite similar to those in Seattle, there being about 125 miles of equivalent single track. There are extensions to the suburbs of Spanaway and South Tacoma and to Puyallup, Old Tacoma and Steilacoom.

Track and Roadbed Systems.

In Seattle are 33 city lines, including three cable routes. A standard city construction is in use where the tracks are in pavement. Trolleys are, as a rule, No. 00 round copper and practically all standard.

Where it is possible, in the commercial districts, span wires are fastened to eye-bolts placed in building walls, otherwise support is had from tubular iron poles. In the outlying districts wooden poles are used. Feeder wires in some of the downtown districts are run underground from the substation and are carried up the side of the building to the span connecting thereto. At other points feeders are carried on four-pin arms mounted on the iron poles. In the residence and suburban districts the feeders are carried on Light and Power Department poles, or those jointly owned

SPECIFICATIONS OF CARS IN SEATTLE

Style of car	Class	Capacity	Inside finish	Trucks Make	Trucks Style	Wheels Material	Wheels Diam.	Motors No.	Motors Style	Controllers	Gear ratio	Brake	Fenders	Weight	Built by
Single end, double truck...	600	56	Cherry	S.M.T.,	C60	steel,	34"	4,	GE-80	GE-K28	15-71	Nat. air Pea. hand	S. E. Co.	54,800 lb.	St. Louis Car Co.
Double end, double truck...	500	48	Cherry	Brill,	27G	steel,	34"	4,	GE-80	K28 & K6	15-71	Chr. air Pea. hand	S. E. Co.	46,440 lb.	St. Louis Car Co. & Brill.
Double end, single truck...	100	26	Oak	J. & S. Brill		cast,	33"	2,	GE-58	GE-K10	17-67	hand	S. E. Co.	18,400 lb.	Jackson & Sharpe & Brill.
Double end, cable, double truck...	...	34	Ash Span. cedar	Hammonds		cast, spoke	22"	1	grip	2 ends	....	wheel track	S. E. Co.	12,000 lb.	Hammond.
Freight, double truck...	400	40,000 lb.	fir	Brill,	27G	cast,	33"	4,	GE-58	GE-K6	17-67	air hand	S. E. Co.	.....	Seattle Electric Co.
Wrecker, box car, single truck...	400	12,000 lb.	..	Brill,	21E	cast,	33"	2,	GE-1200	GE-K2	17-67	hand	S. E. Co.	.....	Seattle Electric Co.
Line box car, single truck...	400	.....	fir	Peckham		cast,	33"	2,	GE-1000	GE-K10	17-67	hand	S. E. Co.	.....	Seattle Electric Co.
Freight, "Totem," double truck...	400	40,000 lb.	fir	S.M.T.,	C60	steel,	33"	4,	GE-57	GE-K14	17-71	straight auto hand	S. E. Co. S. M.	78,700 lb.	Seattle Electric Co.

S. M. T. stands for Standard Motor Truck Co.
S. E. Co. for Seattle Electric Co.

Number of cars:

Passenger Motor Cars	400
U. S. Mail Motor Cars	2
Passenger Cable Cars	55
Freight and Construction Motor Cars	26
Freight and Construction Flat Cars	50

with other companies. There is but a small amount of bradset suspension and that in an outlying district.

Trouble on trolley lines is cared for by three line cars, and a two-horse railway tower wagon is held in reserve.

Track in Seattle:

Number of routes	33
Miles of equivalent single track	198.91
Mileage in paved streets	102.55
Mileage in unpaved streets	96.36
Miles of trestle	14.67
Number, Chetham electric switches	39

Type of rails used in Seattle:

Paved streets, present standard, 80 lb. T, Lorain, Section 335.
Paved streets, 72 lb. T, Lorain, Section 331.
Paved streets, 62 lb. T, Pennsylvania, Section 242.
Paved streets, guard rail (special work), 113 lb., Pennsylvania, Section 234.
Unpaved streets, 60 lb., A. S. C. E. Standard.
Cable lines, 40 lb.
Standard rail joint, Continuous.

The Seattle and Tacoma Interurban has a length of about 34 miles, although in both cities the cars run over the local lines to the city limits, so that the actual length is somewhat greater than this.

This line after passing through Georgetown takes a southerly course and serves Renton Junction, Kent, Auburn, Milton and smaller stations. At Kent and Auburn are depots, the former being of some pretention. The depots and shelter stations are frame structures and vary in design and finish.

The roadbed has a gravel ballast, the ties being of native timber. The rails are 72 lb. Lorain, section No. 331. The system operates entirely third-electric rail between the city limits. This rail is heavy, being 100 lb. steel and is supported on a cast iron, fibre insulated track insulator. There are numerous sidings, as the road is single track for part of the distance. From Tacoma to Auburn is single track, from there to Thomas it is double tracked, where it becomes again single and continues thus to Renton Junction. From this latter point into Seattle it is double tracked. The total equivalent single track is about 60 miles.

At road crossings a ringing signal is used. This is supplied by the National Electric Manufacturing Company. It is operated from a circuit which is closed when the car or train passes a short section of electric rail placed on the opposite side of the track from the third rail. The bell continues to ring until contact is again made with another similarly placed rail on the further side of the bell. At the Tacoma end of this system is a section of catenary trolley, otherwise all trolley is of ordinary type.

Electric Signal Rail on Seattle-Tacoma Line.

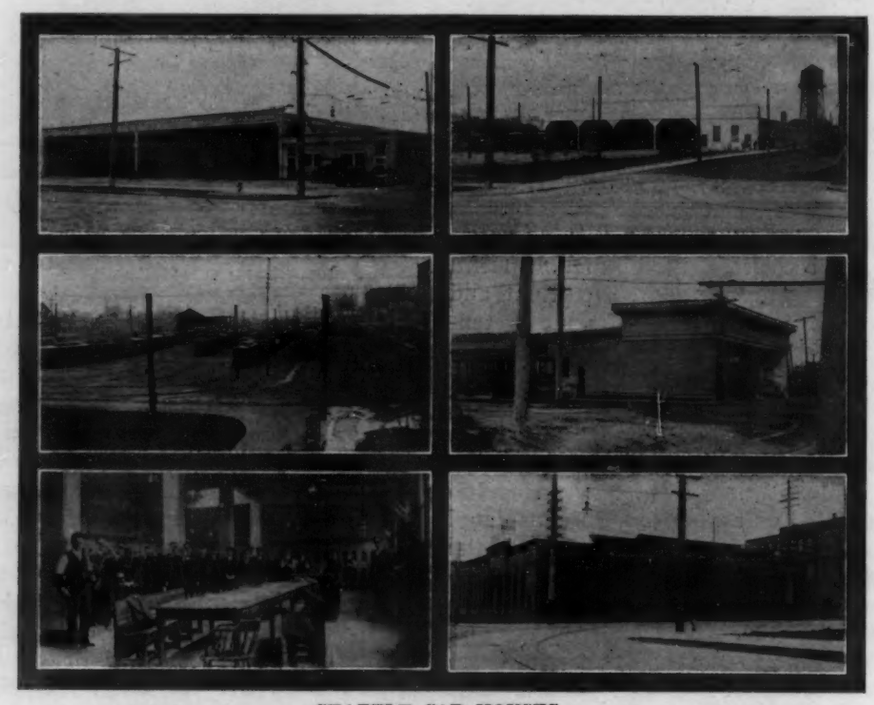
The Seattle and Everett Interurban Railway, which was formerly known as the Pacific Northwest Traction Company, has recently entered the Stone & Webster consolidation. The system, commencing at the northern limit of Seattle, runs in a northerly direction to the city of Everett. There is one branch line two miles long to the Seattle Country Club and this line is operated by that institution, although the cars and operators are supplied by the railway company. Cars of this system after arriving at Seattle are run over the city lines to a station in the business center. At the Everett end is a substantial brick depot containing waiting rooms and tickets offices and in the second story are the executive offices of the road. Two tracks are carried into the station, an umbrella shed being provided for the protection of passengers while entering and leaving cars. The road is picturesque, passing through a dense forest of firs which tower to a great height on both sides of the right of way and give the impression of traveling through a splendid avenue.

Building the Belingham-Skagit Line Along Puget Sound.

When first built this line extended only to Howell Lake, 12 miles from the city limits. It was built with 60 lb. rails and of not as good construction as was later adopted. When the line was extended to Everett the old line was straightened and given a better grade. The line now is well ballasted with gravel. The ties are of hewn native timber. The rails on the old section are 60 lb., but on the new section from Howell Lake to Everett are 70 lb. standard A. S. C. E. section, with continuous joints. Stub cattle guards are used. This is a local device and consists of several rows of 2 in. x 6 in. planks cut in short sections and placed on end so that they incline to the horizontal about 60 degrees Short sidings are frequent and at Howell Lake is a corrugated iron substation equipped with one standard 500 kw. synchronous motor generator set. A 13,800 volt, three-phase aluminum circuit equivalent to No. 00 copper is carried at the top of the trolley poles on one side to this station. This line comes from the substation at Ballard. The poles on one side are 45 ft. long and have two arms, the upper carrying the transmission circuit, while the lower arm, 10 ft. below, carries a telephone circuit and a 750,000 c.m. aluminum trolley feeder. On the other side the poles are 25 ft. long and are given a heavy rake. The trolley wire is No. 00 copper.

A novel road crossing signal is installed on this line. It consists of an illuminated sign with the words, "Stop, car coming." This is lighted on the approach of a car by twelve 16 c.p. incandescent lamps, wired on two circuits from the trolley. In operation contact is made by means of an insulated rail section from which two wires are brought to the shelter station at the crossing. At this point is a 22-cell storage battery which receives a constant charge through a series of four c.p. lamps. There are two 4-point switches operated by solenoids. The action of the car closes a circuit which actuates the first solenoid, the second, acting as a relay, closes the light circuit and at the same time connects the battery in series with the lights. By this means the battery is kept fully charged.

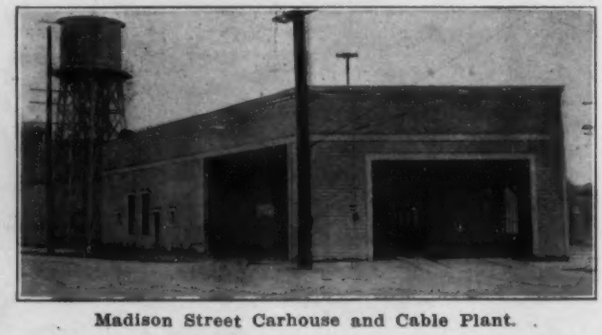
The length of the line from the Seattle city limits to Everett is 23 miles. From the Seattle depot to the



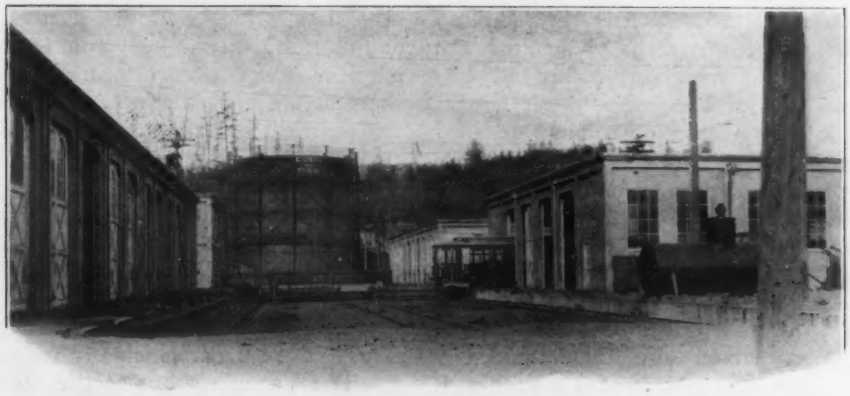
SEATTLE CAR HOUSES.

North Seattle.
Storage Yard at North Seattle.
Men's Club Room at North Seattle.
Tenth and Jefferson Streets, Seattle.
Fremont.
Tacoma.

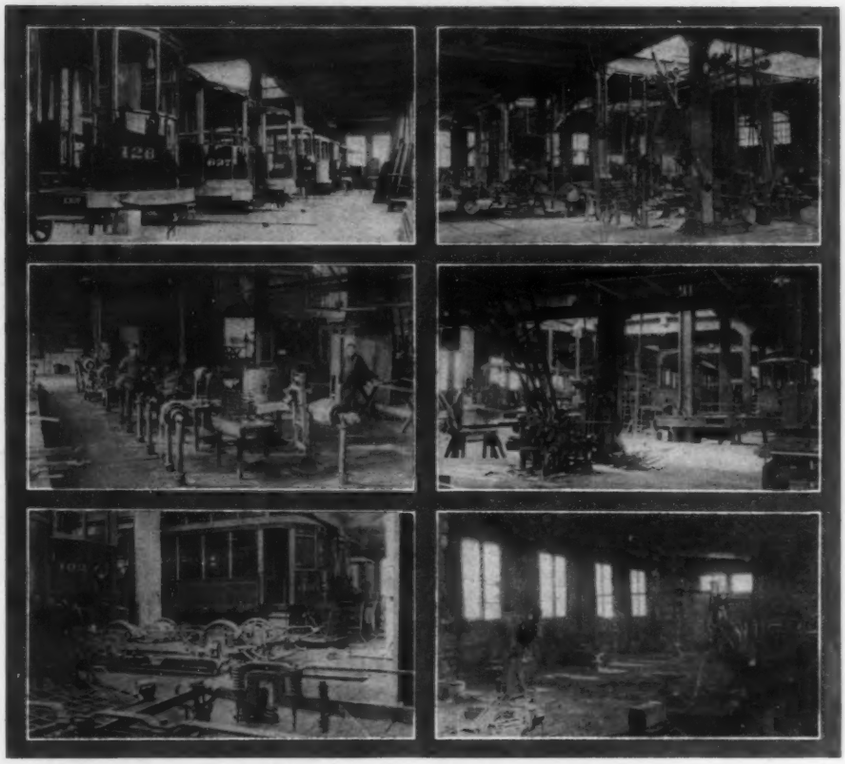
Yesler Way Cable Driving Plant.



Madison Street Carhouse and Cable Plant.



Georgetown Carshops.



INTERIOR VIEWS GEORGETOWN CAR SHOPS.

Paint Shop.
Armature Shop.
Assembly Department.
Machine Shop.
Carpenter Shop.
Forge Shop.

city limits is about 6 miles. Freight is handled at night, there being two regular trains each way. Lumber products are handled principally.

Bellingham-Skagit Railway is now under construction. It is to be modern and of high class construction, extending 27.5 miles from Bellingham to Burlington and Mt. Vernon. From Burlington there is to be a 5-mile branch line to Sedro-Wooley. A catenary trolley construction is to be used, supported on brackets from a single line of 45 ft. poles.

A three-phase, 55,000 volt transmission line of aluminum, equivalent to No. 1 copper, will be carried at the top of the poles for the supply of the two substations at Clayton Bay and Burlington and this transmission line will be continued from Burlington a distance of 28 miles to Concrete, to supply power to Portland cement mills, where 4000 kw. transformer capacity is to be installed.

The Bellingham city railway has 23.9 miles of equivalent single track. Ordinary span trolley, No. 00 round copper is used. There are about 50 cars operated of which 25 are motor cars for passenger service, the remaining are miscellaneous, trailers, freight, repair cars, etc.

Car Houses and Car Shops.

The car houses are at various points on the system suitable to the requirements of operation. Aside from storage or washing and cleaning, very little, if any, repair work is done, this being left for the shops at Georgetown and Tacoma.

As the car houses are natural points where the car operators congregate, the company has considered

the proper organization of social pursuits and comforts as of prime importance towards efficiency in operation and conducive to a close friendly feeling which it is the policy of the company to maintain toward all employees at all times. All of the principal car houses are equipped with lounging and club rooms, provided with comfortable arrangements for lunching and bathing. Each club room is equipped with lockers for every man whose run may bring him to the car house and a billiard and pool table. Bulletin boards in the club rooms are so placed that communications and other directions may be posted for careful perusal by the men and communication between headquarters and operators is easily maintained and understood. A school of instruction for new men is also maintained.

In all of the car houses are track pits, and these, as a rule, are under nearly all of the tracks in the house. The Shuffleton system of cast iron track mounting is used in all pits. This consists of an "A"-shaped cast iron yoke every few feet under the rail, the latter being supported on a heavy timber. This mounting makes practically a clear space under the entire track system.

A novel experimental car washing system designed at the Georgetown shops consists of a revolving brush 8 ft. long and 24 in. diameter. It stands vertically and is moved, revolving, along the side of the car by suitable mechanism. Water is delivered from the center of the brush.

The car houses, their capacity, material of building, etc., are given in the following table:

* Sprinkler system. † Shop. ‡ Transfer table.

Name.	Car cap.	Wash rack.	No. tracks.	Crane.	Pit tracks.	Bld.
Seattle		cap.				
Tenth and Jefferson*†	40	2 cars	8	25 ton	7	frame
do storage yard	30	.....	7	.....	..	.....
North Seattle†	48	2 cars	12	.....	12	re-con.
do storage yard	128	.....	16	.....	..	.....
Fremont	36	2 cars	6	.....	4	brick
do storage yard	40	.....	8	.....	..	.....
James Street Cable‡	6	1 car	4	.....	..	brick
Madison Street Cable‡†*	12	1 car	4	.....	..	frame
Yesler Way‡	48	1 car	11	.....	..	frame
Kent Interurban†‡	15	.....	3	.....	3	frame
Tacoma, Shop‡†	30	2 cars	6	.....	4	brick
do storage yard						

The main shops of the system are at Georgetown, a suburb at the southernmost limit of Seattle. These shops are arranged on both sides of a straight pit, throughout the length of which operates an electrically driven transfer table. The buildings, with the exception of the forge and brass founding houses, which are of corrugated iron, are of reinforced concrete panel and column construction which present a neat and substantial appearance. On the north side are the paint shop, store rooms and offices and wheel grinding apparatus. The paint shop has a capacity for 20 large or 30 mixed cars and is well equipped for good work. The store room has a large capacity and a careful system of accounts and segregation of the myriad supplies is practiced here. The wheel grinding machine, which is used for resurfacing car wheels, is an apparatus in which there is an adjustable mandrel carrying two emery wheels, which are rapidly revolved by means of a belt drive actuated by a 15 h.p. induction motor.

To the south of the transfer table are the carpenter, machine and armature shops, forge shop and brass foundry. The carpenter shop has a capacity for about 20 cars and is equipped with the various wood-working machines necessary for modern equipment. The armature shop, which occupies part of the machine shop building, is always a busy spot in a railway system and requires a high class of work. In front of this is the sheet metal, air-brake and controller shop where specialized skill is also required. The machine shop has a capacity for about 15 cars. In the equipment are 1 car-wheel lathe, 6 machine lathes, 2 shaping machines and 3 planing machines. These are all motor driven. In the rear of the machine shop is the forge shop. This contains 9 forges, 1 power hammer, 1 babbitt heating furnace, emery grinders, etc.

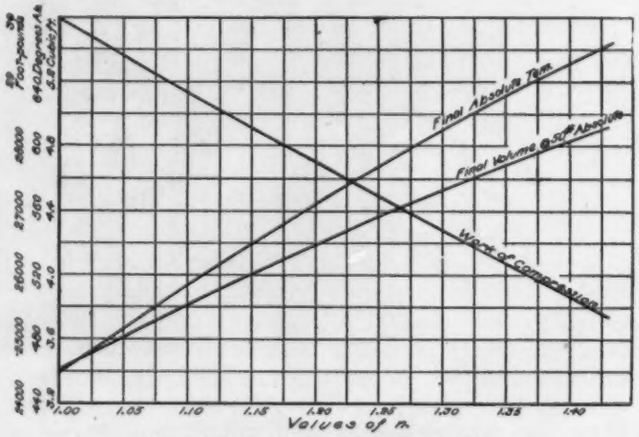
These shops are prepared to build cars if necessary, but are used principally for repair work.

The Tacoma shops at the central station and car house are equipped for repairing the cars of the local system, but not to such a scale or extent as may be done at the Georgetown shops.

WORK OF COMPRESSION OF ONE POUND OF AIR.

BY F. E. PERNOT.

In the operation of the air compressor it often becomes necessary to introduce a factor denoting the work of compression of one pound of air. This work varies, as is generally known, according to the exponential law of compression under which the air is forced. The following data is useful for problems of this nature involving the compression of air according to any exponential law between isothermal and adiabatic compression.



Compression of One Pound of Air.
From 14.7 lb. abs. along curve $P V^n = K$.

Compression from 14.7 lb. sq. in. to pressure of 50 lb. per sq. in. (absolute). Initial temperature = 0.00 deg. F. = 459.6 deg. F. (absolute.)

Compression along curves $p v^n = K$.

R for air = 53.37.

$p v = R T$ $p_1 = 14.7$ $T_1 = 459.6$ $v_1 = 11.59$ cu. ft.

$v_2 = v_1 (p_1 / p_2)^{\frac{1}{n}}$ $p_2 = 50.00$

$T_2 = p_2 v_2 / R$

W = work of compression as given by indicator card.

$W = p_1 v_1 \log_e (v_2 / v_1)$ for particular case of n = 1.00

$W = \frac{p_2 v_2}{n - 1} (1 - (v_2 / v_1)^{n-1})$ for other values of n.

W given in foot-pounds.

Tabulating.

Values of n.		T_2 abs.	T_2 F.	v_2 cu. ft.	W ft. lbs.
Isot.	1.00	459.6	00.00	3.4065	30,031
	1.10	513.7	54.10	3.8078	28,875
	1.20	563.6	104.00	4.1779	27,759
	1.30	610.2	150.60	4.5228	26,693
	1.40	652.1	192.50	4.8333	25,676
Adiab.	1.406	654.5	194.90	4.8514	25,612

The above results are shown on the curve.

WESTERN LAWS OF ELECTRICITY AND WATER

COURT ASSISTANCE IN ESTABLISHING JUST WATER RIGHT ADJUDICATION.

BY A. E. CHANDLER.

Previous papers of this series have shown the distressing situation in quieting title to water right benefits in California and other western states. Mention has been made of the fact that relief is largely to be found, not in legislation, but in broad minded decisions of the courts. It will be interesting and at the same time instructive before proceeding with further water-right discussion, to relate at this time the details of a remarkable water-right decision (Hough vs. Porter, Ore., 98 Pac. Rep. 1083) allusion to which has been made in previous papers.

In the little-known region of South Central Oregon is a short mountain stream caller Silver Creek, which empties into a lake of the same name. Although its summer flow is but slightly in excess of ten cubic feet per second, Silver Creek is destined to be one of the best known mountain streams of Oregon, on account of an opinion of the Supreme Court of Oregon, dated January 5, 1909, in the case of Hough vs. Porter.

This suit was originally instituted in the Circuit Court of Lake County on April 14, 1900. There were originally two parties plaintiff and one party defendant. The judge of the Circuit Court, believing that the controversy could not be properly determined without the presence of other parties, ordered that all those using the water of Silver Creek should appear as parties to the suit.

The case finally reached the Supreme Court and an opinion was handed down in May, 1908 (Hough vs. Porter, 95 Pac. Rep. 732). At the close of this opinion it is stated that the records disclose that none of the lands were settled upon till 1878, which is subsequent to the passage of the Congressional Desert Land Act. The court further stated that "it is a serious question whether this Act does not abolish the common law rule relative to the doctrine of riparian rights, so far as its interpretation has been applied to irrigation of lands to which title has been acquired since that Act became a law." The court therefore concluded to continue the case for further argument, in accordance with which order further argument was submitted and the final opinion fiiled, as stated above, on January 5, 1909 (98 Pac. 1083).

The Desert Land Act was passed on March 3, 1877, and provides in brief that any person possessing the necessary qualifications may secure "a tract of desert land not exceeding one section, by conducting water upon the same, within the period of three years" after filing his declaration. Among the provisos included in the Act is the following: "And all surplus water over and above such actual appropriation and use, together with the water of all lakes, rivers and other sources of water supply upon the public lands, and not navigable, shall remain and be held free for the appropriation and use of the public for irrigation, mining and manufacturing purposes, subject to existing rights." This clause of the Act is the one upon which the court desired a more extended argument.

In its opinion the court makes an able and extended argument on the provisions of a number of Congressional Acts, beginning with the Act of 1866, protecting vested rights which had been "recognized and acknowledged by local customs, laws and the decisions of the courts." It concludes as follows: "Construed, then, with the Act of 1866 and other provisions of the Act of 1877, we are of the opinion that all lands settled upon after the date of the latter Act were accepted with the implied understanding that (except as hereinafter stated) the first to appropriate and use the water for the purposes specified in the Act should have the superior right thereto. So far as we are able to determine, the question, as here presented, has not heretofore been squarely before any of the courts."

Following the above conclusion the court makes an examination of the many cases decided, by both the State and Federal Courts, in which the Desert Land Act of 1877 was considered, and decides that they are in harmony with the above conclusion.

The opinion further states: "But the effect of the language of the Act that 'there shall remain and be held free for the appropriation and use of the public for irrigation,' etc., we think, while constituting words of reservation and dedication, limits the rights thereunder to the deprivation of the riparian lands of the water only in so far as it may be claimed by the riparians for the purposes there enumerated. One of the rights inseparable from the land has always been that the owner of such land was entitled to an adequate supply of water flowing over it for domestic use, together with sufficient for the domestic animals necessary for the proper subsistence and maintenance of the landed proprietor and his family." The above statement is followed by a detailed argument in which the court attempts to justify its position that the mere settlement upon land riparian to a stream "gives ample notice that the water for all necessary domestic uses is, and will continue to be, demanded as appurtenant to the land entered, as much so as would a diversion of the water for such purposes." This is the exception referred to in the conclusion above quoted.

The opinion in this case is noteworthy for features other than the riparian doctrine. The court has shown a most modern view of the use of water for irrigation. The water rights are determined for the irrigated lands instead of for the ditches, as has been so wrongfully done in other water right decisions. An excellent exposition of the "duty of water" is given, and the decrease in the amount of water necessary, due to the introduction of improved methods and the length of time for which lands have been irrigated, is fully recognized. The duty of water actually accepted in the opinion is about one cubic foot per second for

eighty acres, which is certainly a step towards economy for a mountain community.

In insisting that all users of water from Silver Creek be made parties to the suit, the court determined in this one action the rights of every one interested. Had the action as originally brought been decided, only the rights of three parties would have been adjudicated, thus leaving the way open for a multiplicity of suits and continual contention over the alleged wrongful diversions of the waters of the stream. At the time this suit was brought (1900) there was no specific statute authorizing a court to require all parties interested in the waters of a stream to be brought in. Such a statute was passed in 1905. In this case the court relied for its authority upon a general statute.

In states which have not adopted modern legislation in regard to the protection of water rights, one of the most serious defects has been that even though a court might decide in a single action the rights of all parties using the waters of a stream, the decree would be of little value, as no public officer is provided to see that the provisions of the decree are carried out. In the present case the court realized this defect and held that "the court below should, in order to protect the rights of all the parties, or their successors in interest, enter such supplemental decree or decrees as may be necessary for that purpose; and, if at any time deemed necessary by it, the court should require the sheriff, or other officer or person as it may designate for the purpose, including an engineer or other assistant, as may be required, to fix at the points of diversion or other proper places suitable boxes or headgates, with a view to being able, in accordance with this decree, properly to measure, regulate and distribute the water between those who, under this decree, may be entitled to the use thereof, the costs for which should be taxed against each in such proportion as the court may deem just and equitable."

There are four essential features to be covered by an irrigation code. They are, first, that beneficial use should be the measure and limit of the right to the use of water and that said right should be appurtenant to certain designated lands; second, a direct and inexpensive method for the determination of existing rights; third, provision for the diversion of the stream flow according to priorities in time of scarcity; fourth, the control of all new appropriations by a state engineer. The Supreme Court of Oregon, in the case considered, covers in its opinion the first three features enumerated above. Legislation by the State of Oregon incorporating these features would, therefore, be merely declaratory of the law of the state as laid down in this opinion.

RECEIPTS FROM TRACKLESS TROLLEYS.

The cost of constructing trackless trolley systems in England was given by a recent lecturer as $15,000 per mile of route, as against $50,000 per mile for the usual rail system. The cost of working is about 11 cents per car mile. Receipts depend upon local conditions. At Leeds they were given as 21 cents per car mile and at Bradford 16½ cents.

MOTOR APPLICATION.[1]

BY W. S. HOAG.

This embodies a very broad subject—a volume might be written on each of one hundred distinct phases. The steel mill, the foundry, the factory, the great railroad repair shops, are all subjects we have seen elaborated in the pages of our technical magazines. Nowadays, we might think that a motor is universally and successfully applied wherever electric power is available, but upon closer observation, is this true? Is motor application universal under the lines of a power company? After careful consideration our answer is, "No, it is not universal—only partially so."

Permit me to call your attention to the two broad divisions of this subject—the things that are for and the things that are against the universal application of motors. The important things that are tending to promote universal application of the motor are, first, the power companies.

Every up-to-date power company has its well organized "New Business Department," equipped with a corps of expert solicitors, whose business it is to sell power to anyone under the company's lines who can use the power and pay the bills. The solicitor is a salesman; directly, he sells electrical energy; indirectly, he sells motors. His duty is to convince his progressive customer that he should use electric power to drive his shop or mill in preference to the steam engine, or the gasoline engine, or the oil engine. After numerous calls, automobile rides, and theater parties, he secures his prospect's signature to the contract and the deal is closed. The power salesman has done a good job; he has earned his salary; he has secured business which means revenue for his employer; the customer is satisfied because he has succeeded in contracting for his power at a few dollars per year less than he could secure power in any other way.

The next most potent factor tending toward the universal application of motors is the motor manufacturer. The manufacturer in most cases, is a large company representing millions of capital, whose very existence depends upon the manufacture and sale, in large quantities, of motors made up from a few standard designs. This company is equipped with a carefully organized sales department, whose branch offices are located in every corner of the globe and whose salesmen are eagerly on the job wherever a market is to be found for a motor. Again, a prospect is discovered, and said prospect in the hands of the professional salesman is soon turned into a good customer.

The third, but less potent factor tending to promote the general application of motors is the great success of the motor itself.

It is very general information that the motor, when properly applied, can do its work more successfully than any other method of drive. It is cheaper to install and more economical to operate. The majority of those who use motors are satisfied with them; that fact in itself is recommendation of the strongest kind.

Secondly: What are the things that tend to prevent the universal application of the motor? They

[1]Paper read and discussed before Los Angeles Section A. I. E. E., April 30, 1912.

are two in number; first, the failures of the motor drive; second, the cases where customer can produce power by some other means more economically than he can buy it of the power company. We will dismiss this subject entirely, as it does not have any bearing on the point to be emphasized; therefore, let us look directly into the causes for the failures of motor drive, and further, let us see who are responsible for these failures.

Causes for failure are:

(a) Insufficient capacity in the line.
(b) Motors improperly selected.
(c) Motors improperly applied.

Now, who are responsible for the failures due to the causes above mentioned? Obviously, the responsibility lies with the power company and the motor manufacturer and the customer. Each one, or all of them may be to blame in any particular case of failure. It is my personal opinion that the causes for ninety per cent of the motor failures are chargeable equally to the power companies and the motor manufacturers. We will therefore dismiss the few cases wherein the customer is to blame, for he is not supposed to know anything about motor drive and in fact always leaves these questions to those who are recommending to him the installation of the motor.

Let us note a number of cases and then we can better judge for ourselves. Let us keep carefully before us the fact that in nearly every case of motor failure, the customer is ignorant of the kind of motor required or the methods of its application and that the engineering information and the motor specifications must come from the power company or from the motor manufacturer.

Example No. 1. The customer, approaching the manufacturer desires to purchase a 30 h.p. motor to drive a certain machines; careful inquiry shows that conditions will be very heavy; the manufacturer recommends the purchase of a wound secondary motor but the power company objects to this, although the wound secondary motor would be easier on the power company's lines than the standard squirrel-cage motor. The power company's reasons for objecting are that the standard squirrel-cage motor is O. K. and they do not want anything special on this installation, as the customer might think that his problem was too special for motor drive. The power company is in a hurry to get the customer fixed up with a motor for fear he will change his mind and buy a gas engine. Thus encouraged by the power company, the manufacturer (a), we will say, will change his squirrel-cage motor, because he knows that the manufacturer (b) will; or if (b) will not, he knows that (x) will, for (x) likes to rush in and grab out an order of this kind and cash in quickly while the market is good. Thus competition forces a quick sale and the motor is promptly installed. The motor takes three times full load current at starting, pulling the line voltage down 40 per cent. Here we have an interesting condition that no automatic protector device manufactured in the United States will fulfill. After the customer has had a couple of burn-outs, costing him approximately $150 each, he discards his motor and installs an engine.

Example No. 2. A man is operating a 200 h.p. in three different units; he has all his motors burned out and has to re-wind them all inside of twelve months. In addition to this, he suffers several thousand dollars' loss in business, all because his motors were not properly selected, properly installed and properly protected.

Example No. 3. In another case similar to the above, a man discarded a 75 h.p. motor and installed an engine in its place; this case, however, was purely customer's fault, as he did not select the proper kind of motor for the work at hand; at least, so the power company said.

Example No. 4. In another case, the motor manufacturer induces customer to buy a motor twice as large as is required to do the work; in this particular case, a motor built on a 25 h.p. frame was purchased to carry a load of approximately 7½ h.p. Average operating efficiency was about 50 per cent, where it should have been 85 per cent. After three months' trial a good live gas engine man can easily sell this party a new gas engine to replace the motor.

Example No. 5. In another case, a large manufacturing concern discarded its old, worn-out steam engine and installed a 100 h. p. motor; this motor is driving 35 different machines through the medium of about 200 feet of heavy line shafting and its accessories —pulleys and belts. This company's power bill for the first year was pretty high and showed little economy over steam; to remedy their troubles, they discarded the one large motor and installed four smaller ones. This helped matters considerably but it is obvious that maximum economy can be obtained only from the use of 35 different motors. It would be a crime to put a good live steam engine salesman on this job, for I fear he would get the order.

Why are these cases failures? Simply because the motors are incorrectly selected or improperly installed. A word of admonition to both power company and motor manufacturer would point out to them that while no one disputes their right to extract from their customers every dollar they can get, yet such absolute disregard of the fundamental principles of electrical engineering as has been cited above can have only a detrimental effect on the power and motor industry in the long run. If new business nowadays were not so easily obtained, perhaps more attention would be given to the lost business and the causes occasioning such loss. Would it now be wiser, in view of these conditions, to replace some of the power salesmen and the motor salesmen with expert consulting engineers, whose duties would be to seek out and recommend a remedy to these live, steam engine and gas engine prospects? Why should not every motor user be an enthusiast on motor drive?

What is the remedy for these conditions? Obviously, the employment on the part of the motor user of a disinterested and competent consulting engineer to solve his problems, draw his specifications and to assist in purchasing the proper kinds of apparatus to successfully perform the work. The engineer would then take charge of the installation of the apparatus and would see that it was properly protected from both electrical and mechanical injury. Acting in this capacity, the consulting engineer would readily solve this problem of the business relation of customer, manufacturer and power company to the end that failures in motor application would be less frequent than they are today.

HIGHER EFFICIENCY AND LOWER RATES.

BY GEORGE A. DAMON.

The men who are engaged in the technical department of the business must be expected to make great advances. Do you know that the total efficiency from the heat units in the fuel oil burned under the boilers in the Long Beach plant through all the processes of transformation of energy until it leaves the incandescent lamp in the form of light rays is only six-tenths of one per cent? Now the little firefly makes its light practically without any heat loss. It is very nearly cold light and has an efficiency of almost 100 per cent. Now I know that the men who are engaged in the technical end of the business are making great improvements. Since the introduction of the tungsten lamp, for instance, the amount of light per kilowatt hour has been increased three-fold. The completion of the Long Beach Steam Plant will enable you to produce power at a cost less than it has ever been generated by steam in this district, but you will readily see that there is still the greatest opportunity for the reduction of rates through the increase of the technical efficiency of your equipment. The subjects discussed at these monthly meetings of the employes of your company show that you are awake to your technical problems and possibilities, but you can still further study the leaks in your generating plants; you must lose no opportunities to increase your load factor, your power factor, and your diversity factor; your system of transmission and generation must be arranged to the best advantage and you must give every assistance to your customers in the selection of the proper kinds of lamps and appliances and the proper size and kind of motors so that even after your product is delivered it will be used to the best purpose. What an inspiration that little firefly must be to our technical efforts.

The financial questions involved in the reduction of rates are of equal importance to the technical problems. At the present time it requires about 50 per cent of your earnings to take care of your financial burdens of fixed charges, dividends, renewal fund and the authorization of your investment. Scientific regulation must eventually take care of all these requirements if it is to secure the reduction of rates without the actual confiscation of the property.

Out of your earnings there must first be allowed enough to pay the operating expenses for producing adequate service. There will come a time when new equipment must be purchased to replace the obsolete or inadequate equipment and unless the earnings have been sufficiently large to provide for a renewal fund at the same rate that the depreciation has been taking place, the investment in new equipment must be capitalized and there will be a pyramided capital account containing more than one dollar of investment for each dollar's worth of equipment, so that the second requirement of financial efficiency means an adequate depreciation account.

The next part of the financial problem is to pay the interest upon all bonds or other evidences of debt, and in addition to pay dividends which will represent a fair return upon a certain amount of actual investment and also something more than mere interest charges in order to compensate for the enterprise of starting and carrying on the business. It should be recognized that a fair return must be something greater than just ordinary mortgage interest rates.

Now one of the fundamental principles of regulation in the future must be that, if this rate of return upon the investment is to be limited, then the actual investment in the property must be absolutely protected. In other words, that if the fixed charges and profits of the business are to be reduced to their lowest terms, then public regulation, in order to secure the lowest rates, must protect the investor and the greatest measure of financial efficiency will not be reached until this result has been obtained.

In addition to the financial requirements already mentioned public regulation should insist upon the accumulation of a surplus. We would not think much of any other business if it was run upon such a narrow margin that it would have no surplus available to take care of contingencies such as unexpected accidents, temporary losses of the business due to panic conditions, etc. In fact the opinion is gradually being reached that scientific regulation can be obtained in no better way than by the public control of such a surplus fund. This method of control would secure its results by first insisting that the companies earn a surplus and in order to make this surplus as large as possible, every detail of operation and every requirement of the financial arrangements must be thoroughly scrutinized. The accumulation of this surplus would, at once, remove a large part of the hazard in the business from the shoulders of the investors and by thus acting as an insurance fund should reduce the "cost of money" to a low limit. Furthermore, after this surplus had assumed sufficient proportions, it could act as a measure by means of which the public regulating bodies could control the development of the business. For instance this surplus fund could be used for any of the following purposes: to enter the lines into non-paying territory somewhat in advance of actual need; to provide modern improvements even before the old equipment has been entirely worn out; to decapitalize that part of the investment which represents development expenses or to reduce the rates. I believe it will be perfectly possible in the future, by the wise administration of such a surplus fund, to do all of these things. If rates are not reduced too fast, the increase in the technical efficiency which is bound to come, and the lower rates of return which can be secured by protecting the investment, can be combined to produce net earnings which may be used by the public for the continuous and automatic reduction of rates.

REDUCTION IN SAN FRANCISCO TRANSBAY TELEPHONE RATES.

The State Railroad Commission has obtained from The Pacific Telephone & Telegraph Company a cut of 33 1-3 per cent in the toll charges between San Francisco and the cities of Oakland, Alameda and Berkeley. The present rate is 15c for a conversation of three minutes. Beginning July 1st, this rate will be cut to 10c for a conversation of three minutes.

HIGH AND LOW PRESSURE HEATING—QUESTIONS AND ANSWERS.

Journal of Electricity, Power and Gas:

In reference to the two systems of underground heating which are now being installed in San Francisco and Oakland, I would be glad to have the relative merits of both systems discussed from a standpoint of economy for revenue.

The low pressure system utilizes the exhaust steam from a steam turbine or engine, which exhausts directly into the line against about six or seven pounds back pressure. With this method they have an income from the sale of generated current and exhaust steam. In the high pressure system, the steam is turned direct from the boiler into the high pressure lines at from ten to one hundred pounds gauge pressure. In this case, they have a revenue only from the sale of steam for heating systems and an occasional opportunity to operate steam driven pumps which have already been installed in buildings to which they sell steam.

Believing there is an opportunity for further study on above systems, would ask to have the relative merits discussed in your valued paper.

1. Which system is the most economical and pays the best revenue?
2. Has the high pressure system any gain in commercial heating value over the low?
3. Will there not be a greater condensation loss in the high pressure system on account of the higher temperature?
4. What is the relative amount of condensation in each system?
5. What is the relative cost of each system?
6. Which system will have the least number of shutdowns due to leaks, and will not the high pressure system cost considerable more to maintain?
7. Will there not be a greater revenue from the low pressure when due consideration is given to the returns from the sale of current and exhaust steam?

A SUBSCRIBER.

As my experience has been confined entirely to low pressure system of steam distribution it is not possible for me to make authentic comparisons. However, I will reply to your questions numerically, as completely as possible.

1. By "economical" I presume is meant the distribution efficiency. With a low pressure system the radiation per sq. ft. of pipe surface is undoubtedly less than with high pressure, but the larger mains required by the low pressure system afford considerable more surface for radiation, so that I would look for really more condensation per block of street mains in the low pressure system. Exhaust steam is, of course, saturated or contains a certain percentage of water in suspension. High pressure steam, on the other hand, may be somewhat superheated when leaving the stations and this superheat may neutralize radiation to such an extent that but little steam is condensed in the system adjacent to the stations. I think, however, that the deciding feature of economy between the two systems is that of leakage. The low pressure system can be kept perfectly tight, whereas it is, apparently, difficult to keep the high pressure system free from leaks. A small leak in a system carrying over 50 lbs. of steam will discharge an enormous amount of steam.

2. I think there is practically no difference in the commercial heating value of the two types of service. High pressure steam has to be ultimately reduced to low pressure for building supply and while it may carry sufficient heat to slightly superheat when passing through the reducing valve, I would not expect this to be the case.

3. As stated in reply to No. 1, this will depend upon the quality of high pressure steam. If same is superheated there would probably be a greater condensation per sq. ft. of surface, due to the greater radiation. Per block of system, however, I think the low pressure system would show greater actual condensation.

4. I have no data from which to compare condensation of high and low pressure systems.

5. Concerning cost—I have no data from which to make comparisons, but I would presume cost of high pressure system as compared with low pressure would be in about direct proportion to the pipe sizes involved.

6. The low pressure system if properly installed requires absolutely no shut down except to connect new services. The maintenance of the system is practically nil. I have no information as to shut downs or maintenance of the high pressure system.

7. This will depend upon the relative prices of steam and electricity, the water rate of the electric generating units operating against back-pressure as compared with condensing units, and the relative costs of the steam and electric systems.

Yours very truly,

J. G. De REMER,

Chief Engineer, United Light & Power Co.

PROPOSED POWERS FOR ONTARIO HYDRO-ELECTRIC SYSTEM.

A bill has been introduced in the Provincial Legislature of Ontario conferring on the hydroelectric commission the following powers, among others:

To take over existing power-transmission lines and to improve water powers, by assisting municipalities and others in the storage of water, making of sluices, etc.; to regulate the installation of electrical equipment and of wires in all building, including private houses; to control absolutely light and power rates charged by municipalities whether these municipalities take power from the commission or not; to direct the disposal of surpluses earned by municipal power plants supplied by the commission; to order all wires under its jurisdiction to be laid underground in cities and towns; with the co-operation of the Dominion Railway Commission, to order to be laid underground all wires in streets where the municipalities construct tunnels or conduits to carry such wires.

JOURNAL OF ELECTRICITY
POWER AND GAS

PUBLISHED WEEKLY BY THE

Technical Publishing Company

Rialto Building, San Francisco

E. B. STRONG, President and General Manager
A. H. HALLORAN, V. P. and Managing Editor
ROBERT SIBLEY, Treasurer and Editor in Chief
C. L. CORY, Secretary and Special Contributor
A. M. HUNT, Director and Special Contributor

On Library Cars of all Southern Pacific Trains.

TERMS OF SUBSCRIPTION

United States, Cuba and Mexico	per year,	$2.50
Dominion of Canada	"	3.50
Other Foreign Countries within the Postal Union	"	5.00
Single Copies, Current Month	each	.25

NOTICE TO ADVERTISERS

Changes of advertising copy should reach this office *ten days in advance of date of issue.* New advertisements will be accepted up to noon of Monday dated Saturday of the same week. Where proof is to be returned for approval, Eastern advertisers should mail copy at least thirty days in advance of date of issue.

Entered as second-class matter at the San Francisco Post Office as "The Electrical Journal," July 1895.
Entry changed to "The Journal of Electricity," September, 1895.
Entry changed to "The Journal of Electricity, Power and Gas," August 15, 1899.
Entry changed May 1, 1906, to "The Journal of Electricity, Power and Gas," Weekly.

FOUNDED 1887 AS THE
PACIFIC LUMBERMAN, CONTRACTOR AND ELECTRICIAN

CONTENTS

Puget Sound Traction, Light and Power Company's System. 511
By Rudolph W. Van Norden.
Work of Compression of One Pound of Air 552
By F. E. Pernot.
Court Assistance in Establishing Just Water Right Adjudication 553
By A. E. Chandler.
Receipts from Trackless Trolleys 554
Motor Application 554
By W. S. Hoag.
Higher Efficiency and Lower Rates 556
By George A. Damon.
Reduction in San Francisco Transbay Telephone Rates 556
High and Low Pressure Heating 557
By J. G. De Remer.
Proposed Powers for Ontario Hydroelectric System 557
Editorial 558
- Welcome N. E. L. A.
- The Lake Tapps Affair.
- Over-All Efficiencies.
- Commission Doings on the Coast.

Personals 560
Reservations on Golden Poppy Special 561
Entertainment for N. E. L. A. Delegates at San Francisco.. 561
California Electrical Contractors' Notes 561
Errata Notice 561
Industrial 562
- New Benjamin Fixtures.
- Immense Power Plant Project.
- The Gem Irrigation Pumping Equipment.
- Baltimore and Ohio Install More Telephones.

Book Reviews 563
- "Public Utilities Act of California."
- "Mathematics of Applied Electricity."
- "Valuation of Public Utility Properties."

News Notes 564

Welcome N. E. L. A.

According to the Standard dictionary, one of the meanings of the good old Anglo-Saxon word "willa-cuma" or welcome" is the privilege to use and to enjoy. Such is the welcome the Journal desires to extend to the guests of the west; namely, the delegates to the Seattle convention of the National Electric Light Association now daily arriving from every city of our great country. Indeed such a welcome but bespeaks the love we all have for our brothers—the wise men from the east. Did we but use the word in its usual sense merely meaning that of "a hearty greeting given" no longer would we be true to western ideals and traditions.

The privilege to use, to enjoy.

What a world of meaning wrapped up in one word —"welcome"!!

Even now every mountain pass is alive with special trains bearing weary men to western hospitality. A year of faithful, painstaking planning has been put in by those having in charge the great convention soon to be called to order. Every indication points to a profitable program and an enthusiastic gathering.

You men of the east come to us with your older traditions. With experiences gained by hard knocks of an older community, and with a wealth of business ideas many of which we hope to absorb in our few days' mingling together. We of the west, on the other hand, have but two things to offer—one is the "gimp" and vivacity of youth and the other is a home with us in a land of opportunity.

Hence, bearing in mind these two offerings, the Journal, in behalf of your western brothers, extends to you a hearty good Anglo-Saxon "willa-cuma"—the privilege to use and to enjoy.

Over-all Efficiencies

When the words, "consider the ant, thou sluggard" were formulated by the inspired writer in the Good Book, it is hardly possible that he had in mind the casting of caustic remarks at the achievements of the modern engineer. Yet, on another page of this Journal Dean Damon of Throop Polytechnic Institute, tells us that the light-giving efficiency of the cousin of the ant, the fire-fly, is almost 100 per cent, whereas, of the energy generated at the Long Beach plant of the Southern California Edison—a plant possessing the most efficient equipment known to modern invention—only six-tenths of one per cent actually appears at the receiving end in useful light for the consumer.

In considering the over-all efficiency of the modern electric generating steam auxiliary, in other words in considering the ultimate ratio of actual light energy produced, to the energy known to be inherent in a pound of crude petroleum fired beneath the boiler, the paltry figure resulting is indeed striking. Especially is this true in face of modern wanton boasts raising engineering achievements skyward.

A number of factors enter into the combined or over-all efficiency in power plant economies. Some of these have been wonderfully improved in recent years. Indeed some factors seem so near perfection, it is a

question whether they can be improved materially without radical and at present unknown changes in methods of power generation.

In recent well authenticated tests it has been found that modern high grade boilers may operate with a total loss of less than 17 per cent. In a word, 82 per cent to 83 per cent of the available energy is found in the heat of the steam leaving the boiler. Again in conducting the steam to the steam turbine, about 90 per cent of this available steam finally enters the impeller blades.

At the turbo-generator, though this is apparently a wonderfully efficient mechanism, only 21 per cent is delivered in power from the terminals and after allowing for auxiliary apparatus, it is better to say only about 18 per cent is actually delivered. Finally, after deducting the energy lost in journeying through the step-up transformers, then over the transmission lines and through the step-down distributing transformers and measuring devices we find that only about 60 per cent of this energy reaches the consumer. But in converting electrical energy into electro-magnetic phenomena the actual light rays visible to the human eye comprise only 5 per cent of the total energy. Hence the actual energy available in terms of energy generated is

$.83 \times .90 \times .18 \times .60 \times .05 = .0067$ or .67 of one per cent.

In scanning the above the third and last factors are the most glaring inefficiencies, yet struggle and think as the inventive genius of man has done in the past half century, no means as yet have proved practicable. The only solution from a thermodynamic standpoint is to attack the problem from an entirely different point.

As to the improving of the latter factor, a world of opportunity awaits the inventor. No hit and miss discoverer, however, will ever chance upon its solution. He who wears the laurels for solving this question, namely that of converting electric energy into electro-magnetic light waves of length attuned to the visual range of the eye, thus transforming all energy into light, will undoubtedly be so akin to the infinite that he can readily solve the adverse problem. This adverse problem is that of converting efficiently electro-magnetic waves into other forms of energy—thermal, mechanical and heat, thereby opening to man's use a power so sweeping as to be almost beyond human conception. The radiated energy of the sun, known to be equal to 7000 horsepower per acre of earth's surface, would become available.

With such worlds of power at our command, we all could then say with T. A. Edison: "4 A. M. and nothing to do till morning."

The Lake Tapps Affair

It appears that a $40,000 concern on the White River threatens to enjoin through the courts the operation of the new $12,000,000 power plant at Lake Tapps, near Tacoma, a description of which project appears as part of the Puget Sound Traction, Light & Power Company system described elsewhere in this issue.

In the publicly regulated utility company the issue is not that of a $12,000,000 corporation pitted against a weak brother of but $40,000 in assets, but rather should the consideration be that of the greatest good to the greatest number of people.

It may be true that a man who formerly floated some small logs and shingle bolts acquired certain vested rights in a stream, but surely in equity it could never be proved as just and proper or in accord with principles of conservation of national energies and efficiencies to restrain a publicly regulated utility of millions invested, supplying human necessities to thousands of living souls. In a word the question at issue is not one of prior rights but one opposing public policy.

Commission Doings on the Coast

The first fruits of commission regulation are already evident. An educational campaign setting forth the scope and powers of the new commission is resulting in the favorable consideration of California securities by eastern financiers. During the past several months eastern bankers have sent personal representatives to the Coast in order to investigate the far-reaching effects of commission legislation in Washington, California and other western states. California, in particular, has been the recipient of unusual scrutiny, and as for the personnel of the California State Railroad Commission, it is doubtful if ever in their lives these five men have been as carefully appraised and rated as has been the case during this period of inspection. Indeed, if these five men appraise and rate public utility companies and their physical assets as thoroughly and as fairly as these investigators have passed upon them, and every reason is evident that such will be the case, satisfaction will result on all sides.

The financial houses on the Coast, especially those institutions largely engaged in placing California public utility securities, have done much to aid an early and correct publicity in regard to the recent public utility act. No small amount of credit is due one of the leading bonding firms of San Francisco for their earnest endeavors along these lines. A handsomely bound volume of three hundred pages, a review of which is found elsewhere in these columns, has been compiled and published by this enterprising firm, and distributed gratuitously among their friends and clients. This book deals throughout with the public utilities act of California, the personnel of the new commission and its function toward the people and toward the public utility corporations.

The gathering of accurate facts and figures concerning new commission legislation in the western states and the broadcast dissemination of this literature cannot help raising western securities to their proper position in the financial world. A sane, thoughtful, considerate realization of fundamental principles of right and justice has come over the big men representing commission and corporation interests alike. Little harm or injustice can possibly result when such is the case.

The more widely this feeling of mutual self-confidence is felt throughout eastern financial circles, the better for all concerned, and to all those aiding in this campaign much credit is due.

PERSONALS.

George Cole, of John R. Cole & Co., is visiting the trade at Los Angeles.

Samuel Insull, president of the Commonwealth Edison Company of Chicago, is at San Francisco.

T. H. Dooling has recently been transferred from the Portland to the San Francisco office of Pierson, Roeding & Company.

F. E. Blanchfield, sales manager of the American Ever-Ready Company, with headquarters at San Francisco, is taking a vacation in the mountains.

H. C. Hazzard, the service expert of the electrical department of the State Railroad Commission of California, has been appointed, also, assistant attorney to Attorney Max Thelen.

S. L. Shuffleton, engineer in charge of construction for Stone & Webster at the Big Creek plant of the Pacific Light & Power Corporation, left Fresno, Cal., this week for Seattle.

Matt Comerford, of New York City, the general president of the International Union of Steam Engineers, spent the past week at San Francisco on an official visit to the Pacific Coast.

H. C. Goldrick, Pacific Coast representative of the Kellogg Switchboard and Supply Company, will spend the coming week in an automobile trip to Los Angeles and return, transacting business en route.

H. B. Taylor, chief engineer of the hydraulic department of the Cramp's shipbuilding yards at Philadelphia, is at San Francisco, in company with **Henry S. Grove**, the head of the plant, on a tour of the Pacific Coast.

P. H. Coolidge, general commercial superintendent of the Pacific Telephone & Telegraph Company, and **C. W. Burkett**, general superintendent of plant, are making an inspection of the company's system in the Pacific Northwest.

P. D. Fraser, formerly high tension sales engineer with the General Electric Company at Portland, Ore., was recently appointed general foreman of operation and maintenance for the Great Western Power Company at San Francisco.

Geo. A. Damon, engineer with Bion J. Arnold, and dean of Throop Polytechnic Institute, delivered a paper before the Throop branch of the A. I. E. E. regarding "Technical Opportunities of Southern California" on May 31st at Los Angeles.

J. N. Mahoney, head of the switchboard department of the Westinghouse Electric and Manufacturing Company, who is out from Pittsburg on his first Pacific Coast tour, spent the past week at the San Francisco office of the company instructing the local men in the switchboard apparatus details.

John A. Britton, general manager of the Pacific Gas & Electric Company, and several heads of departments, spent last Tuesday and Wednesday, at Santa Rosa in connection with the hearing before the State Railroad Commission of the company's protest against the Great Western Power Company entering that city with a competing transmission system. Officials of the latter company were also on the ground to present their defense of their position.

J. B. Lukes, representative of the Stone & Webster Construction Company and The Truckee River General Electric Company, and **E. B. Bumstead**, engineer with Stone & Webster, have opened offices at 1211 First National Bank Building, San Francisco. The purchasing office for the construction of the Big Creek power plant of the Pacific Light & Power Corporation will be maintained in the Rialto Building, San Francisco, under the direction of **F. T. Berry**.

P. T. Hanscom, electrical engineer with the Great Western Power Company, and **A. G. Jones**, sales engineer with the General Electric Company, have been elected to serve two years, and **C. L. Cory**, professor of electrical engineering at the University of California, one year on the executive committee of the San Francisco Section of the American Institute of Electrical Engineers. The remaining members are **H. W. Crozier**, electrical engineer with Sanderson & Porter, and **A. H. Halloran**.

H. L. Cory left for the south last Tuesday. He will deliver an address at the annual meeting of the Sigma Xi Engineering Society of the University of Missouri, explaining why the damming of the Colorado river was a failure. He will, also, visit Purdue University at La Fayette, Ind., where he will attend a reunion of his class to which George Ade and other dstinguished men belonged. Later he will visit Augusta, Georgia, and render his report to the Flood Commission regarding the prevention of flood damage from the Savannah River.

Nearly every one of the 1912 graduates of the department of mechanical and electrical engineering at the University of California secured a position within ten days after graduation. This fact refutes the statement that is made, from time to time, by uninformed persons, to the effect that a large proportion of college graduates in these lines do not prove their ability by securing and holding good positions. To show the nature of the positions obtained, the following names and business locations are appended:

E. A. Abeel, engaged in hydraulic work with Marquardt & Galloway, consulting engineers at Big Bend plant of Great Western Power Company; J. B. Black, commercial department Great Western Power Company, San Francisco; A. F. Bridge, construction work for the General Electric Company in rebuilding a transformer at Isleton; F. E. Pernot, engineering corps of Pacific Telephone & Telegraph Company, at San Francisco; W. P. Custer, gas department Pacific Gas & Electric Company, Potrero Works, San Francisco; A. V. Guillou, distribution department, Pacific Gas & Electric Company at San Rafael; W. S. Heger Jr., interested with F. T. Mumma, 5124 Grove street, Oakland, as electrical engineer in connection with electrical installation and irrigation pumping work; Mr. Czarnecki, construction work, Pacific Gas & Electric Company; B. M. Mehl, distribution department, Pacific Gas & Electric Company, at Sacramento; R. W. Mueller, assisting G. C. Noble in testing work for Pacific Gas & Electric Company; G. E. Noyes, Southern Pacific Company's shops' at Sacramento; J. F. Pollard, assisting G. C. Noble in testing work for Pacific Gas & Electric Company; L. S. Ready, underground construction work, for Pacific Gas & Electric Company at Oakland; H. E. Sandoval, distribution department at University of California; E. A. Slater, gas department Pacific Gas & Electric Company, Potrero works; C. M. Smith, engineering department Pacific Telephone & Telegraph Company, at Portland; J. E. Wallace, in charge of stock supplies for a mining company at Virginia City, Nevada; W. D. Wolfe, drafting department United States Navy Yard, Mare Island; J. P. Zipf, with engineering force of Sierra & San Francisco Power Company.

CALIFORNIA ELECTRICAL CONTRACTORS' NOTES.

Frank Watts, manager of the McFell Electric Company, who was operated on a few weeks ago for appendicitis, has been removed from the hospital to his home and expects to get out again shortly. Judson McFell arrived from Chicago Thursday evening and attended the co-operative dinner. He will look after things until Mr. Watts is around.

The Standard Electric Company were awarded the clock, telephone and bells on the Girls' High School job for the sum of $2780.

The Southern Pacific and the Santa Fe Railroads have made a special rate of one and one-third fare from all points in California for the round trip to San Jose at the time of the annual convention of the State Electrical Contractors' Association. Going tickets will be on sale July 14th to 27th, inclusive, and returning certificates (when properly validated) will be honored and tickets sold at the one-third fare from July 24th to August 1st, inclusive.

RESERVATIONS FOR GOLDEN POPPY SPECIAL.

The following reservations have already been made on the "Golden Poppy Special" to the N. E. L. A. Convention at Seattle, June 10-14, 1912, from California:

R. H. Ballard, wife and daughter, Southern California Edison Company; E. M. Beal, Great Western Power Company; T. E. Bibbins, General Electric Company; Frederick Booth, Pacific Electric Heating Company; G. H. Bragg, Pacific Gas & Electric Company; A. U. Brandt, Pacific Gas & Electric Company; W. W. Briggs and wife, Westinghouse Electric & Manufacturing Company; John A. Britton, Pacific Gas & Electric Company; J. D. Butler, Pacific Gas & Electric Company; W. W. S. Butler, Western States Gas & Electric Company; Geo. A. Campbell and wife, Truckee River General Electric Company; R. J. Cash, General Electric Company; S. K. Colby, Pierson, Roeding & Company; John R. Cole, John R. Cole Company; C. F. Conn, J. G. White & Company; F. J. Cram and wife, Electric Appliance Company; E. R. Davis, Pacific Light & Power Corporation,; P. M. Downing, Pacific Gas & Electric Company; W. E. Durfey & Wife, San Joaquin Light & Power Corporation; C. A. Eastwood, Pacific Gas & Electric Company; W. E. Elliott; T. E. Fogelsang, Pacific Gas & Electric Company; Fred George, Pacific Gas & Electric Company; F. B. Gleason, wife and child, Western Electric Company; W. L. Goodwin, Pacific States Electric Company; F. S. Gray, Pacific Gas & Electric Company; E. R. Hallett, Louis Sloss & Company; Arthur H. Halloran and wife, Journal of Electricity, Power and Gas; F. G. Hamilton, Mt. Whitney Light & Power Company; W. W. Hanscom, San Francisco; Harry Hays, Mt. Whitney Light & Power Company; John Coffee Hays and wife; Carl Heise, Westinghouse Electric & Manufacturing Company; R. D. Holabird, Holabird, Reynolds & Company; J. H. Hornung, Great Western Power Company; A. M. Irwin and wife, Westinghouse Electric & Manufacturing Company; W. V. Jahant, Acampo, Cal; A. G. Jones, General Electric Company; H. H. Jones, Los Angeles; Mr. Junges, San Francisco; G. I. Kinney, Fort Wayne Electric Works; Phil Levy and sister, Levy Electric Company; J. A. Lighthipe, Southern California Edison Company; H. T. Markey, Great Western Power Company; C. E. Maynard, Great Western Power Company; Mr. Miller, Acampo, Cal.; H. M. Mosher, Pacific Gas & Electric Company; F. S. Myrtle, Pacific Gas & Electric Company; E. H. Mulligan, Los Angeles; F. H. Murray, National Carbon Company; A. J. Myers, Wagner Electric Company; L. H. Newbert, Pacific Gas & Electric Company; E. R. Northmore, Los Angeles; L. N. Peart and wife, San Joaquin Light & Power Company; Ralph Phelps, Safety Ins. Wire & Cable Company; H. P. Pitts, Pacific Gas & Electric Company; F. H. Poss, Benjamin Electric Manufacturing Company; C. G. Pyle and wife, Standard Underground Cable Company; E. A. Quinn, Allis-Chalmers Company; J. W. Redpath, Southern Pacific Company; H. A. Russell, General Electric Company; S. P. Russell and wife, H. W. Johns-Manville Company; A. B. Saurman, Standard Underground Cable Company; Robert Sibley and wife, Journal of Electricity, Power and Gas; E. Spraul, Great Western Power Company; F. Stone. General . Electric Company; B. T. Story, Los Angeles; A. V. Thompson, General Electric Company; A. R. Thompson, Pacific Gas & Electric Company; G. S. Thompson, Great Western Power Company; J. Thompson, Pacific Electric Manufacturing Company; J. A. Vandegrift, National Electric Lamp Association; J. W. Van Huysen, General Electric Company; J. W. Varney, Pacific Gas & Electric Company; E. B. Walthall and wife, San Joaquin Light & Power Corporation; S. V. Walton, Pacific Gas & Electric Company; C. J. Wilson, Pacific Gas & Electric Company; J. H. Wise, Pacific Gas & Electric Company; A. E. Wishon and wife, San Joaquin Light & Power Corporation; Garnett Young, Telephone & Electric Equipment Company.

The tickets for these reservations and any ones that may be subsequently made, may be purchased at the office of the Southern Pacific Railroad at Market and New Montgomery streets on and after Monday, June 3rd.

ENTERTAINMENT FOR N. E. L. A. DELEGATES AT SAN FRANCISCO.

The delegates to the Seattle convention of the National Electric Light Association on the Red Special from Boston and New York, via the Grand Canyon of the Colorado and Pacific Coast cities are to be entertained at Los Angeles as detailed in these columns last week.

When they arrive at Del Monte on June 4, they will be met by a committee from the Electrical Development League of San Francisco. Enroute to San Francisco each guest will be decorated with an artificial California poppy bearing the imprint "San Francisco 1915." These guests will be met at San Francisco on the evening of the 5th, by automobiles and taken to the Hotel St. Francis, where California fruits, flowers and wines will be placed in their rooms.

On the morning of the 6th automobiles, provided by the Chamber of Commerce, will be in waiting for a trip through the city with luncheon at the Cliff House, the cars being placed at the disposal of the guests for the balance of the day. At 7.15 in the evening an elaborate banquet and vaudeville will be served at the St. Francis Hotel. On the 7th a trip will be made to Mt. Tamalpais with lunch at the tavern and on Friday evening the train will continue on its way to Seattle.

ERRATA NOTICE.

Geo. J. Henry has called attention to a number of errors in his article on "The Development of the Tangential Wheel," which appeared in our issue of May 25th, which are corrected as follows: Formula (4), p. 494 should read:

$$H.P._T = \frac{62.4\,Q\,h}{550} = \frac{62.4}{550}\,\frac{v^2}{2g}\,Q \quad \ldots\ldots\ldots\ldots (4)$$

Formula (5) p. 495 should read:

$$H.P._\mu = \mu\frac{62.4}{550}\,Q\,h = .1134\,Q\,h\,\mu = .001763\,v^2\,Q\,\mu \quad \ldots\ldots (5)$$

The matter commencing with formula (9) p. 495, and extending to the bottom of the page, should appear as follows:

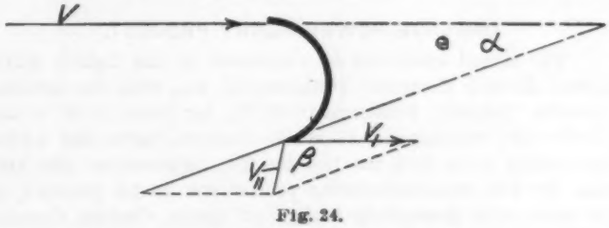


Fig. 24.

There is a velocity remaining in the water discharged from the sides of the bucket equal to

$$(v - v_1)\cos a - v_1 \quad \ldots\ldots\ldots\ldots (13)$$

The velocity which causes the impulse is then v — this loss or

$$v - [(v - v_1)\cos a - v_1] \quad \ldots\ldots\ldots\ldots (14)$$

and the force of impulse

$$F = \frac{w}{g}\,(v - [(v - v_1)\cos a - v_1]) \quad \ldots\ldots\ldots\ldots (15)$$

Now if $v_1 = \frac{v}{2}$ and if $a = o$, conditions sought to be obtained in tangential bucket design (15) may be written.

$$F = \frac{W\,v}{g} = \frac{124.8}{144}\,\frac{a\,v^2}{2g} = .866\,h \quad \ldots\ldots\ldots\ldots (16)$$

Which as shown by formula 8 is twice the static pressure when the wheel pitch circle is running at 50 per cent of the spouting velocity.

INDUSTRIAL

NEW BENJAMIN FIXTURES.

Two new light fixtures of importance to the trade have recently been placed upon the market by the Benjamin Electric Mfg. Co. of San Francisco. The first consists of a deep bowl enameled steel reflector and a two-piece receptacle, and is intended to cover a range of lamps from 25 to 250 watts. Each reflector is suitable for two sizes and adapted for a maximum extensive distribution at approximately 40 degrees. They are particularly useful in shop lighting where it is desirable to protect the operators' eyes against direct rays; 7, 8, 9 and 11 in. sizes are furnished.

Deep Bowl Reflector Socket.

Sign Reflector Socket.

The second fixture is a new sign reflector socket consisting of an integral enameled steel reflector measuring 11⅝ in. across the opening and set in position at an angle to secure an even light distribution on a vertical sign board. Either 60 or 100 watt lamps may be used.

Both devices may be equipped with the company's lamp grip consisting of a simple spring means which engages the lamp base with sufficient force to hold it in position. This feature is of particular value in places where the lamp socket is subjected to any considerable vibration.

IMMENSE POWER PLANT PROJECT.

The recent execution of a contract by the Lehigh Navigation Electric Company, Philadelphia, Pa., with the General Electric Company, Schenectady, N. Y., for three 10,000 k.v.a., 11,000 volt, three-phase, 25 cycle, complete horizontal turbo-generating units with the two 300 kw. turbo-exciter sets and one 300 kw. motor-generating exciter set, to be installed in its new main generating station at Hauto, Carbon, County, Pa., is significant of the progress of active constructive operations in the inauguration of the largest electrification project since the establishment of the Niagara Falls power plants.

Aside from the size of this work for the centralization of power generation and distribution, which contemplates an initial expenditure of $3,000,000 and definite plans for an eventual investment of $10,000,000, with an assured supply capacity of 20,000 kilowatts from the first installation of the three 10,000 kw. turbo-generators and a gradual enlargement to 100,000 kilowatts ultimate capacity, it represents the beginning of the most novel and important step toward the economic use of coal and the economic generation of electrical power on a tremendous scale by means of fuel that has ever been taken in the United States. Hauto, the site of the central generating station, is about ten miles west of Mauch Chunk and is at the mouth of a railroad tunnel leading from the main body of anthracite coal owned by the Lehigh Coal & Navigation Company at Lansford. From here the distribution of current for heat, light and power by means of high voltage transmission lines, reaching out through all eastern Pennsylvania and New Jersey, will penetrate a territory with 2,500,000 population.

By transforming the effective force of coal into electric energy at the mines and transmitting this direct to consumers and industries, one of the largest factors, the handling, loading, hauling over railroads and dumping, that enter into the cost of coal, will be eliminated. The company figures that still another economic saving will be realized. At present, it has a waste product of about 500,000 tons of coal a year. This consists of coal particles and dust which pass through three-thirty-seconds of an inch mesh screens. All this culm is entirely unmarketable and will be handled so as to be burned in the company's boilers.

The location of the main generating plant at Hauto was also determined because of an abundant water supply. An existing reservoir is being increased to a storage capacity of 1,000,000,000 gallons and an area of about 400 acres by the construction of a high dam. The water supply needs of the ultimate plant will be some 300,000,000 gallons a day, most of which will be carried back into the reservoirs after condensation. To run the plant up to the contemplated maximum installation of 100,000 kw. capacity, it is estimated that 1,000,000 tons of coal a year will be needed, a quantity of anthracite which would require 20,000 of the largest cars to transport to market.

Among the first power consumers in the district, it is planned to supply the slate and cement industries in Lehigh and Northampton counties, all of which are in a territory from twenty to forty miles distant from the Hauto plant. Substations will probably be established at once at Coplay and Pen Argyl for stepping down and distributing the current to users. Within a radius of fifty to seventy-five miles from the main station there are some twenty large cement mills. The transmission lines will be strung largely along the Lehigh Navigation Canal and on the right of way of the Lehigh and New England Railroad, which the company controls.

With the assistance of these companies a complete power census of the industries has been taken, and within the district which will be reached by the distribution system of the first section of the Hauto plant, over 100,000 horsepower is being used now. The Lehigh Navigation Electric Company has made up a schedule of prices, running from eight mills up to some two and a half cents per kilowatt-hour according to the amount of power contracted for and the steady continuance of consumption, which will deliver its current quite materially under the cost at which the industries are able to produce steam power.

Under the laws of Pennsylvania the right of an electric power company operating with steam to distribute energy is confined to a single township; accordingly, charters have been obtained in Lehigh, Schuylkill, Carbon, Northampton, Bucks and Montgomery counties for about sixty electric companies.

With the exception of the 8,000 kilowatt plant of the Harwood Electric Company, which supplies current for lighting and electric railway operation around Hazelton, using coal direct from its own mines, no attempt has been made heretofore in this country to generate electric current in the coal regions for public service. The Lehigh Navigation Electric Company expects to have the first installation at the Hauto plant in operation before the end of the year. As the capacity of the plant is gradually increased, energy will be carried to Allentown and Easton, Pa., Trenton, N. Y., and undoubtedly finally into Philadelphia. This city is within eighty miles and New York is only 105 miles distant.

THE GEM IRRIGATION PUMPING PROJECT.

Of late years the question of irrigation in the west has become an important one as far as the electrical industry is concerned, owing to the use of electric motors in connection therewith. One of the most interesting developments made recently is that of the Gem Irrigation District, near Boise, Idaho, where it has been decided to build a large power plant for the purpose of irrigating the land and furnishing electric energy to the farmers in that vicinity. The acreage to be irrigated is somewhat indefinite at present, but the water rights permit the irrigation company to provide for the use of 290 second-feet of water at a level of 55 feet above low water in the river, 210 second-feet at a level of 90 feet above low water, and 110 second-feet at a level of 160 feet above that of low water. The pumping station will be situated about fifteen miles from Caldwell, Idaho, in a deep canyon on the Snake River. The power plant, which will be completed in 1913, will be at Crane Falls on the Snake River, near Mountain Home, Idaho.

Electric energy will be generated at 6600 volts stepped up to 66,000 volts and transmitted to the pumping station 65 miles distant where it will be reduced by Westinghouse transformers to 2200 volts for application to the pump motors.

The Crane Falls Power & Irrigation Company, which will install and operate the necessary pumping and electric machinery for furnishing both water and power to the farmers of this district, has placed a large contract with the Westinghouse Electric & Manufacturing Co., induction motors, as follows: Three 1025 h.p., two 700 h.p., two 330 h.p. and two 255 h.p. Nine panel control switchboards and six 300 k.v.a. oil insulated self-cooled transformers, as also ordered.

For such irrigation as will be done during the season of 1912 power will be purchased and it is anticipated that the company's power plant will be in operation by 1913. Smith, Kerry & Chase of Toronto, Canada, and Boise, Idaho, supervised the engineering features and drew the specifications for the equipment. The International Steam Pump Company was awarded the contract for the pumps and, as above stated, the Westinghouse Electric & Manufacturing Company secured the contract for the pump motors and transformers.

BOOK REVIEWS.

Mathematics of Applied Electricity. By Ernest H. Koch Jr.; size 7½x5½ in.; 651 pages; 316 illustrations; cloth binding. Published by John Wiley & Sons and for sale by the Technical Book Shop, Rialto Bldg., San Francisco. Price $3.00.

The author—an instructor in mathematics, School of Science and Technology, Pratt Institute, has ably developed in this book the essential elements of algebra, plane gemoetry, plane trigonometry, and elementary principles of mechanics, heat and electricity. The subject matter is treated in three main divisions: The transformation and interpretation of formulas involving direct current problems; graphs of formulas and the formulation of graphs; and vectors and vector diagrams in treating alternating current problems. The purpose held in mind by the author is to bring to the student's attention the underlying basic structure of electrical phenomena so that he may formulate them, interpret them physically and work with accuracy and facility in making numerical and graphic computations. The book will prove useful to engineers desiring a ready reference to mathematical principles thus involved.

Valuation of Public Utility Properties. By Henry Floy; size 9x6½ in.; 390 pages; replete with diagrams and tables. Published by McGraw-Hill Book Company and for sale by the Technical Book Shop, Rialto Bldg., San Francisco. Price $5.00.

Henry Floy, member of the American Institute of Electrical Engineers and American Society of Civil Engineers, as a consulting engineer needs little introduction to the engineering profession. Mr. Floy's paper on Depreciation presented before the annual convention of the A. I. E. E. in June, 1911, created a profound impression and has been quoted most favorably in many technical discussions during the present year. The book at hand starts with a glossary on definition of terms in current use in valuations. The different phases of the subject matter—appraisals, expenses, franchises, goodwill, going value, depreciation—then follow in logical sequence. Since it frequently happens that the valuations of utility property are submitted to the scrutiny of the courts, references are frequently made in this book to the judcial rulings which, though at times contradictory and somewhat confusing, nevertheless indicate the general lines along which valuations must me made in order to render them unassailable. Certainly, this book, together with that of H. A. Foster's, recently reviewed in these columns, constitutes the most sound and complete treatment of the subject available in current technical press.

Public Utilities Act of California. Compiled and published by Eugene R. Hallett, manager Louis Sloss & Co., San Francisco. Size 6½x9½ in.; 300 pages; cloth binding. Complimentary Distribution..

No one acquainted with the vivacity and strenuous makeup of the author of this work would hesitate to pronounce it a success even without examining the interior of its covers. The recent commission legislation in California has brought inquiries from all parts of the country relative to the far-reaching effects of the public utility law enacted within the past few months.

Mr. Hallett has in one fell stroke compiled such information on these lines as will answer at once all questions coming to the mind of the investor in California securities. The book opens with an introduction by Hon. Jno. M. Eshelman, president of the commission. A brief biography of the commissioners follows with a discussion of the utility act and its relations to the public by Hon. Max Thelen, attorney for the commission. A chapter on valuation of public utilities is next treated in a masterly manner by H. A. Lardner, Western manager for J. G. White & Co. A brief sketch of the leading railroad and public service commissions of America next appears, which is followed by an exact copy of all legislation in California creating the new duties of the commission. The work closes with a list of the rules of practice and procedure which have just been adopted by the commission. Finally, perhaps, the most important portion of the compilation is found in the complete and comprehensive index at the rear of the reading matter. Louis Sloss & Co. are to be congratulated upon the neat and careful manner in which the work has been gotten together, to say nothing of their enterprise

THE BALTIMORE & OHIO INSTALL MORE TELEPHONES.

The Baltimore & Ohio Railroad, which was one of the pioneers in the telephone train dispatching field, has recently placed another order with the Western Electric Company for selector equipment to be used in extending its facilities for dispatching trains by telephone.

The division to be equipped lies west of Cincinnati, extending from that place to Montgomery, Indiana, and branching off at Seymour, Indiana, to go to Louisville, Kentucky, and Jeffersonville, Indiana. There will be three circuits paralleling each other, one for transmitting train orders, called a "train wire," another for transmitting messages in general, called a "message wire," and a third, a "block wire," to be used to enable the block tower men to get into quick communication with each other. A feature of the message wire is that it is arranged for "intercalling," or, in other words, waystations can call each other.

The apparatus to be used is the Western Electric No. 102-B type selector set, containing the No. 50 type selector. There will be one hundred selector stations so equipped, covering a stretch of approximately 250 miles. In all there will be over 800 miles of circuit, for train, message and block service.

NEWS NOTES

INCORPORATIONS.

LOS ANGELES, CAL.—The La Rica Water Company, $7500, subscribed $25, by H. K. Wheeler, M. Stewart, F. O. Franzier, F. C. Lamb and E. H. Bresee.

LOS ANGELES, CAL.—Seeley Electrical Laboratory, incorporators, W. W. Sweeney, J. E. Seeley, O. E. Campbell, W. D. Wickum, M. T. Terry, C. H. Bradley, J. P. Stockdale; capital stock, $30,000.

EL CENTRO, CAL.—Articles of incorporation have been filed for the South Alamo Water Company, with George C. Richards, John W. Carter and Daniel K. Goode as directors; 4000 shares of stock will be issued of face value of $2.50 a share.

ASTORIA, ORE.—Articles of incorporation of the Elk Creek Light & Water Company have been filed. The incorporators are Orrin Kellogg, Otto J. Kraemer and Lester W. Humphreys and the capital stock is $5000. The principal place of business is to be at Elk Creek.

ILLUMINATION.

VALLEJO, CAL.—Bonds for a $100,000 municipal light and power plant were defeated.

PALO ALTO, CAL.—At the recent bond election among the propositions which carried were: $20,000 for a muncipal light plant, and $12,500 for the machinery to be installed in the plant.

EXETER, CAL.—Bids will be received up to July 10th, for the sale of the gas franchise, applied for granting the right to construct and maintain, for a period of 50 years, gas pipes under and along public highways of the city.

ARROYO GRANDE, CAL.—R. E. Easton has applied for a franchise for a term of 25 years, to furnish and sell to the city, natural and artificial gas, for light heat, fuel and power and to contruct and maintain gas pipes in said city. Sealed bids will be received up to 10th day of July at 7:30 p.m. for the sale of said franchise.

SAN FRANCISCO, CAL.—The Sierra & San Francisco Power Company has been granted permission by the State Railroad Commissioners to buy for $41,200 the Kings City Water, Light & Power Company. This permission was granted with a proviso by the commission that it will not definitely accept the purchase price as a basis for making light and power rates in that locality without a formal investigation at the proper time.

SAN FRANCISCO, CAL.—The Harbor Board has directed Secretary Merle to notify the Pacific Gas & Electric Company, the Pacific Telephone & Telegraph Company and all other electric light and telephone companies to remove all poles and overhead wires on East street from the Ferry Building north to Lombard street. The companies will be advised that they must have all the poles removed and wires laid in underground conduits before January 1, 1913.

ROSEBURG, ORE.—That A. Welch, the Northwest railroad promoter, and power-plant operator, has purchased the Roseburg light and power plant formerly owned by J. L. and S. A. Kendall, of Pittsburg, Pa., is the current report here. In substantiation of the report it is known that "A. Welch & Company," with office address at Winchester, the location of the Kendall plant, have submitted a proposition to furnish the city of Oakland with light and water for a specified term of years.

STOCKTON, CAL.—The estimated cost of a conduit as reported to the Mayor and City Council by Prof. C. L. Cory, consulting engineer of San Francisco, is: underground electric conduit system, $115,768.50, incandescent electrolier lighting system, $96,820.32, total, $213,588.82. Professor Cory states that each post of the incandescent electrolier street lighting system shall contain five 60-watt metal filament lamps, equivalent to a total of about 250 candle power. The estimate is for 551 electroliers.

OAKLAND, CAL.—A saving of $15,000 will be effected in th municipal lighting bill for the coming fiscal year as the city attorney finds that the city can legally enter into a contract with the Pacific Gas & Electric Company as recommended by Commissioner of Public Health and Safety F. C. Turner to the Council. A call for competitive bids for lighting resulted in the Pacific Company filing a bid naming a price of over $15,000 below its bid of last year. The Central Oakland Light & Power Company entered a bid on district No. 5. Although its bid for this particular district was lower than that of its rival concern it was recommended that the contract be awarded to the Pacific company.

TUCSON, ARIZ.—The State Corporation Commission is to be petitioned by the Tucson Chamber of Commerce to investigate the service and rates of the Tucson Gas, Electric Light & Power Company, and the Tucson Rapid Transit Company. The former is accused of exorbitant charges, and failure to live up to the terms of its charter. C. C. Chappelle, president of both companies, has written the president of the Chamber of Commerce that the company now is preparing for the expenditure of $90,000 for the betterment of its system, and in extensions, and asking that the earliest possible action be taken in the official investigation as having an important bearing upon the credit of the corporation.

TRANSMISSION.

VICTORIA, B. C.—The second unit of the B. C. E. R power plant at the Jordan River will be installed at once to meet the demand for power. Each unit of this plant represents about 6000 h.p. The cost of the improvement will be about $500,000.

LOS ANGELES, CAL.—The Aqueduct Advisory Board is discussing general plans for distributing the power to be generated from the Los Angeles aqueduct. Among the tentative plans considered was that of lighting the streets of Los Angeles under a series of assessment districts, but no definite plans were adopted and it is expected that numerous conferences on this subject will be held before plans are adopted.

VISALIA, CAL.—The Mt. Whitney Power Company has begun the construction of a new substation at Lindsay, which, when completed, will cost the company, $50,000. Although the present substation has capacity of 3000 h.p. and was constructed a few years ago with the prospect of a great demand for power in view, it has been found inadequate to supply the demand for power in the community. With a capacity of 10,000 h.p. the new substation will be the main switching plant of the Mt. Whitney system.

SAN FRANCISCO, CAL.—The Oro Electric Corporation has applied to the State Railroad Commission for a certificate of public convenience and necessity for the construction of a transmission and distribution line from its valley plants to San Francisco Bay The application of the Oro Corporation sets forth that it wants to serve portions of Plumas, Butte, Yuba, Sutter, Colusa, Yolo, Sutter, Sacramento, San Joaquin, Calaveras, Contra Costa and Alameda counties. All its franchise rights have not yet been received, it is stated, but the majority have been. The corporation now operates in Oroville and vicinity.

SACRAMENTO, CAL.—An echo of the old rate fight between the Northern California Power Company and the Sacramento Valley Power Company, which finally ended early this year in the Northern California's purchase of its rival, reached the offices of the State Railroad Commission, when the Northern California Power Company filed application to raise its rates. When the two companies were fighting for business, power charges were slashed right and left by both. When the Sacramento Valley Power Company was purchased by the Northern California, the latter immediately restored rates to the old basis effective before the rate war. The public utilities bill went into effect about that time, however, and the Commission immediately ordered the Northern California Power Company to reduce rates to the competitive basis, and refund all charges in excess of the amount it had been applying. This the power company did, it claims, and it has now presented a formal application to raise the rates.

HOOD RIVER, ORE.—"As soon as a right-of-way can be secured from J. H. Koberg, whose ranch surrounds Stanley Rock, from which point an aerial line of the Pacific Power & Light Company is planned to leave this bank to connect with the Husum line of the company in Washington, the management will begin the construction of the overhead transmission line," says Albert Hall, manager of the Hood River Gas & Electric Company of this city. The right-of-way was recently vacated by the Pacific Telephone Company, the lines of which now cross the river by cable. The Pacific Power & Light Company has three lines crossing the Columbia at the following points: Priest's Rapids, Pasco and Pendleton. The Hood River line, which will be 1982 feet, will be the longest over the Columbia. Under the supervision of Chief Engineer Galvani, H. F. Parsons has been busy during the last week with a crew of men resurveying the high power line between this city and The Dalles. P. M. Morse, City Engineer of Hood River County, has just completed the survey for an extension line of the company in the Mount Hood district and a crew of men is now busy in that community stretching the lines.

TELEPHONE AND TELEGRAPH.

ORANGE, CAL.—The Pacific Telephone & Telegraph Company has been granted a 45-year franchise to erect and operate poles and wires upon the public highways of the city.

COLVILLE, WASH.—The Deer Creek Telephone Company has petitioned the county commissioners for a franchise to erect a line in the public highway seven miles out from Gifford.

IMPERIAL, CAL.—The Imperial Valley Telephone Company, an Arizona corporation operating in the Imperial Valley, has asked the State Railroad Commission for permission to advance its rates, especially those on surburban service.

WHITE SALMON, WASH.—The Farmers' Union Telephone Company of Trout Lake has organized and will shortly incorporate with a capitalization of $50,000. They are selling stock for a line to connect with Underwood and across from there to Hood River. John Weingardner is president.

PASADENA, CAL.—The Pacific Telephone & Telegraph Company has petitioned the State Railroad Commission for permission to purchase the plant and capital stock of the Home Telephone Company of Pasadena, naming the price agreed upon as $370,000. The Pacific, in its petition claims to have an option on 4879 shares of the Home's capital stock out of a total of 5190. The price per share agreed upon is $44. The Home company places its valuation of its capital stock at $516,000 and has $471,000 in bonds outstanding, claiming total assets of $1,205,845. The Home company's gross income in Pasadena last year amounted to $128,880.

SEATLE, WASH.—The City Council is calling for data on the merits of different telephones and the cost of installing 20,000. Superintendent of Public Utilities A. E. Valentine is asked to furnish this information. The council also adopted Councilman Hesketh's resolution protesting against restrictions placed upon the citys' rights by the state public service commission in the matter of overhead and underground wiring regulations. The latter provides for a committee consisting of the president of the council, the chairman of the franchise committee and the superintendent of public utilities, to attend the hearing of the state commission and protest against restrictive measures.

SAN FRANCISCO, CAL.—The Pacific Telephone & Telegraph Company submitted minor reductions in a few rates before the Supervisors' telephone rates committee,, but no decision was reached. These changes were as follows: For two-party desk or wall phone, allowing four calls a day for 20c. The charge on each extra message was reduced from 5c to 4c. The same reduction for excess calls was made for the two-party, two-message a day phone, which costs 7½c a day. The new rate, which the company believes will meet a great popular demand, provides a charge of $4 a month for a one-party phone with an allowance of 50 calls a day. Extra calls will be charged for at the rate of 5c each. The committee took the matter under advisement.

PASADENA, CAL.—Steps are being taken rapidly for the consummation of the deal by which the Home Telephone Company will take over the Sunset at an early date. It now appears, however, that this purchase will be purely technical. The Home Telephone Company will be the purchaser, but, from advices received from San Francisco, it is now known that the Home company will be owned by the Sunset stockholders when this purchase takes place. In other words, the Sunset company has secured control of the Home, and will now turn around and assimilate its own corporation. The reason for this is that the Sunset company has no franchise, and, in the event of opposition being raised to a permit to do business being granted, it would have no means of operating. By first purchasing the Home company, it gains full control of the telephone situation, and also has a franchise. Thus, while the latest development of the situation appears, upon its face, to contradict the statement made by President Eason of the Home company, it really confirms it. In confirmation of this W. M. Eason, president, and MacD. Snowball, secretary, of the Home Company, say this is the initial proceeding to working out the merger of the two corporations.

TRANSPORTATION.

PASADENA, CAL.—Representatives of the Pacific Electric Railroad have applied for a 30-year franchise for a double track electric railway on Lincoln avenue.

PETALUMA, CAL.—The Petaluma & Santa Rosa Railway has purchased from George McNear a big tract of land in East Petaluma which has been occupied by the company for a passenger and freight depot, car shops and railroad yards. Surveyors are at work getting maps and estimates along Water street, preparatory for the extension of the road from this city to Point Pedro. Work on the line, which will go through from Petaluma to Santa Rosa, will commence this year, the road to run through by way of Cotati.

SAN FRANCISCO, CAL.—The Board of Public Works has awarded the contract for constructing 43 cars for the municipal railroad on Geary street to W. L. Holman & Company at their bid price of $7700 for each car and $1500 apiece for four extra trucks. The specifications allow 270 days for the completion of the contract, but Vice-President Reiss of Holman Company stated that if wanted the firm would furnish cars ahead of time by putting on two or three shifts of workmen at the factories. It is expected that some of the cars will be ready in September, when the roadbed on Geary street will be about finished.

SACRAMENTO, CAL.—Application has been made to the Railroad Commission by the Northern Electric Railway Company for permission to issue bonds in the sum of $1,100,000. The application states that the company proposes to construct an electric railroad, standard gauge, from Marysville through Colusa to Meridian, in Sutter county, and to bridge the Sacramento River at Meridian. The bonds are to run for 30 years and to carry 5 per cent. Bonds have been authorized by this company to the amount of $1,500,000, of which $150,000 are outstanding. It is now proposed that $1,000,000 be issued, to be used to carry forward the construction work.

SAN FRANCISCO, CAL.—The Board of Public Works has awarded the contract for supplying electric power for the city railroad, to the Pacific Gas & Electric Company on that corporation's bid of 1c per kw. hour for direct current. This bid was considered low, the price being far less than the city could manufacture power for itself. The sums, amounting to hundreds of thousands of dollars, which were to have been expended in constructing a power house and substation for the Geary street road, may now be devoted to extensions of that line. The Pacific Gas & Electric Company offered to supply alternating current for a smaller figure—$0.0085 per kw. hour—but it was considered more economical to accept the 1c bid. The bids for substation equipment and for alternating current were formally rejected, and the Works Board directed the secretary to advertise for bids for the construction of the car house at Geary street and Presidio avenue. These bids are to be opened June 5. The car house is to be built of concrete, and three sets of specifications for it have been provided, bids to be received on each.

LOS ANGELES, CAL.—The special committee of the City Council which conferred with Paul Shoup, vice-president of the Pacific Electric Company, and William E. Dunn, vice-president of the Los Angeles Railway, regarding the San Pedro street franchise and other traffic matters, has instructed Howard Robertson, deputy city attorney, to prepare an ordinance embracing the tentative agreement reached between the railway officials and the committee. This ordinance contains the following proposals: Pacific Electric Company to build a line on San Pedro street from Ninth to 4th street; Pacific Electric and Los Angeles Railway jointly to build from Fourth to Aliso street, where a third rail will be laid for yellow car local traffic; Los Angeles Railway to lay tracks from Aliso to the Plaza, when San Pedro street is opened by the city. City to have right to purchase the lines after expiration of three years from January 1, 1913, on giving one year's notice to railways, on these terms: Within five years, by paying cost of line; from 5 to 20 years by paying 75 per cent of cost; thereafter, on paying value of property; city to grant franchise for this relief free of cost. Routing of cars to be under direction of public utilities board; repairs, if not made by railways, may be made by the public works board and charged to the companies; erection of another passenger station connecting with the present P. E. depot by a bridge across Los Angeles street, with entrance on that street and also through the present P. E. depot; joint expenditure of about $350,000 by the two railways in equipment and buildings; railways to file reports of costs, and the city to make prompt payment on buying the lines.

SAN JOSE, CAL.—The San Jose Terminal Railway Company has filed an application with the State Railroad Commission to sell $950,000 in bonds and 350,000 shares of preferred stock of the par value of $1 per share, with the proceeds of which it is proposed to complete a combined electric and steamship line to connect San Francisco and San Jose. The company, according to its application, figures on an expenditure of $1,300,000 to establish quick interurban service between here and San Jose. The San Jose Terminal Railway Company has an authorized issue of common stock of 1,500,000 shares of the value of $1 each. The full amount is outstanding. It also has an authorized issue of 1,000,000 shares of preferred stock, valued by the company at $1 and 32,800 of these shares are outstanding, according to the application. In addition, there is an authorized bond issue of $1,000,000, of which $50,000 has been issued. The company proposes to construct an electric railway from San Jose through Alviso to deep water beyond the mouth of the Guadalupe River and there connect with steamers for San Francisco. The length of the proposed line is 43 miles—11 miles of rail and 32 of water. Both passengers and freight are to be handled. Combination boat and train service is contemplated to be arranged for quick itnercommunication between San Francisco and San Jose. The company, according to the application, proposes to spend $50,000 for terminal grants, $76,500 for the construction of a wharf at deep water and $335,000 for general construction work, including a drawbridge at Alviso to cost $20,000. The application is signed by John A. Mehling, vice-president, and M. J. Gardner, secretary. The Terminal Company is not a part of the San Jose Railroad Company or the San Jose and Santa Clara Railroad which fell into the control of the Southern Pacific Company in April, 1911.

WATERWORKS.

LONG BEACH, CAL.—Long Beach will soon be equipped with a $120,000 pressure salt water fire protection system.

OAKVILLE, CAL.—An election will be held June 4 for voting on a $6800 bond issue for a municipal waterworks system.

OXNARD, CAL.—The City Trustees rejected all bids for the purchase of $130,000 worth of municipal light and water bonds.

ALHAMBRA, CAL.—A meeting to determine where Alhambra is to get its future water supply is to be called in a few days by the City Council. Engineer T. B. Dower, who has investigated various sources of supply, declares that 11,250,000 gallons per day will be required. The city plans a municipal water system and among those being considered are San Gabriel Valley's Plant, Owens River water and the supply of the Chapman wells.

SALEM, ORE.—H. Hirschberg, of Independence, has filed with State Engineer Lewis application to divert water of the Little Luckiamute River to be used for power for municipal purposes. The application is incomplete, as it does not tell what use will be made of the power derived from the stream, but Mr. Hirschberg said that it will be used to supply the towns of Independence and Monmouth with electrical power and also for irrigation purposes.

SAN RAFAEL, CAL.—The Board of Supervisors of Marin County have fixed June 25 as the date on which the citizens in Southern Marin County will elect five members to a board to examine schemes for a municipal water system. At a meeting last week the Municipal Water District Association elected the following as their candidates for the board: W. G. Morrow of Sausalito, C. J. B. Cheda and Patrick Ross of San Rafael, M. M. O'Shaughnessy of Mill Valley and Congressman William Kent of Kentfield.

BERKELEY, CAL.—That the people of this city may be compelled to pay a still higher rate for their water is the consensus of opinion of the city authorities, although every effort will be made to keep the present rate, which, in itself is considered high. In a report submitted to the City Council the People's Water Company stated that the percentage of profit for the last year was less than 4 per cent and that in order to get a reasonable return on the investment the present rate should be increased by the Council. The present rate for a 4-inch hydrant is $4 a year and the sprinkling rate is 30c per 1000 feet of water. The minimum rate for consumers is $1.50.